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The MagPi

Issue 132 | August 2023 | magpi.cc

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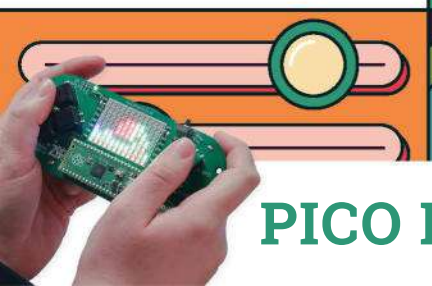
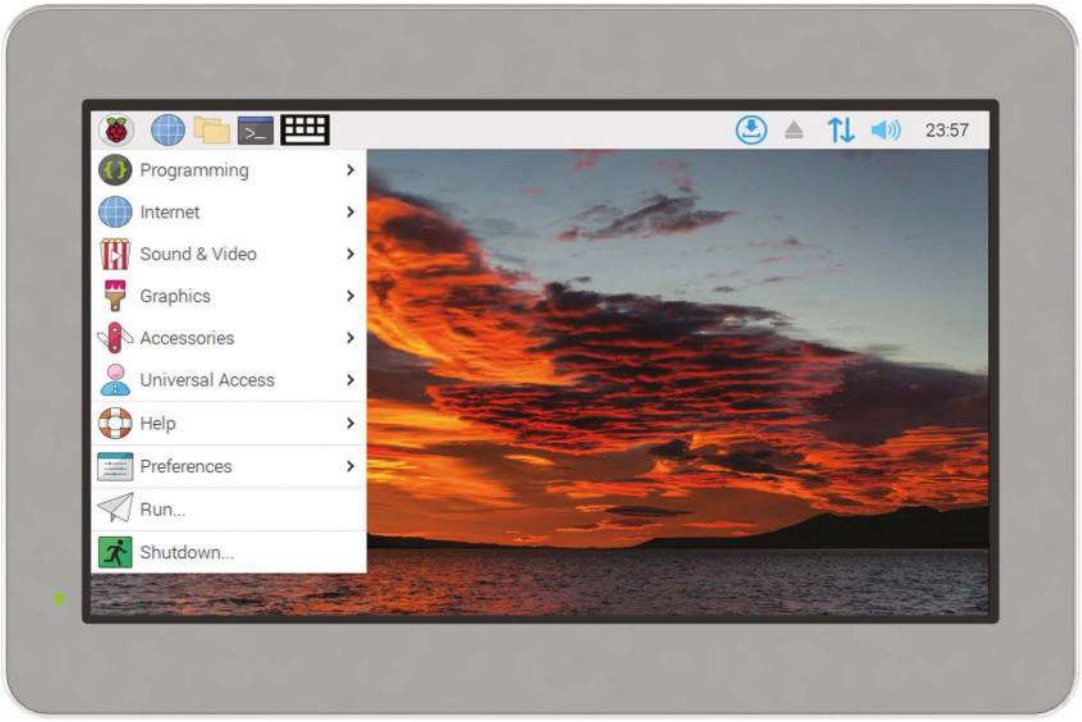


PICO RETRO GAMING WITH KITRONIK ZIP96

UL LISTED

Industrial Raspberry Pi



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COMFILE TECHNOLOGY

WELCOME
to The MagPi 132

Raspberry Pi makes it incredibly easy to build your own Universal Media Player (page 36). There are many reasons to skip a shop-bought box and build your own: obviously, it's cheaper to buy a Raspberry Pi than an expensive media player. But, crucially, it's also better.

Our media player runs whatever streaming services you want, both paid-for and free. You can also add a hard drive or network drive, and stream any media you own. You can even play retro games. Much more importantly: it's rewarding on both a practical and an intellectual level. You'll learn how all of this stuff works!

We're keen on making and learning here at *The MagPi*. Citizen Science is an area where you can use Raspberry Pi to make a difference (**page 58**). From Shake earthquake detection to monitoring your environment, this issue is packed with good things to make and do.

Stay curious and make things.

Lucy Hattersley Editor

EDITOR

Lucy Hattersley

Lucy is the editor of *The MagPi* and has moved from Twitter to Threads. It's all the rage on day one; let's see what it's like next month though.

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GET A RASPBERRY PI PICO W WITH A SUBSCRIPTION! PAGE 30

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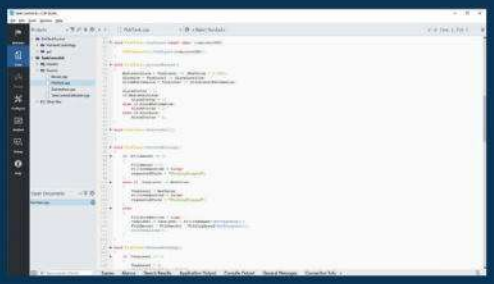
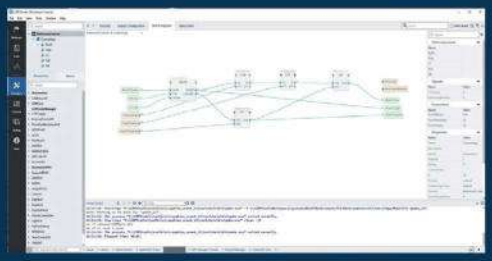


Full-Code



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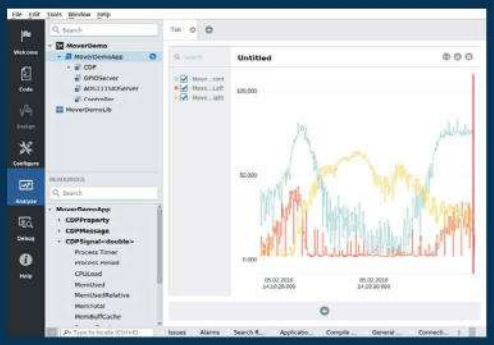
Design



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now with a

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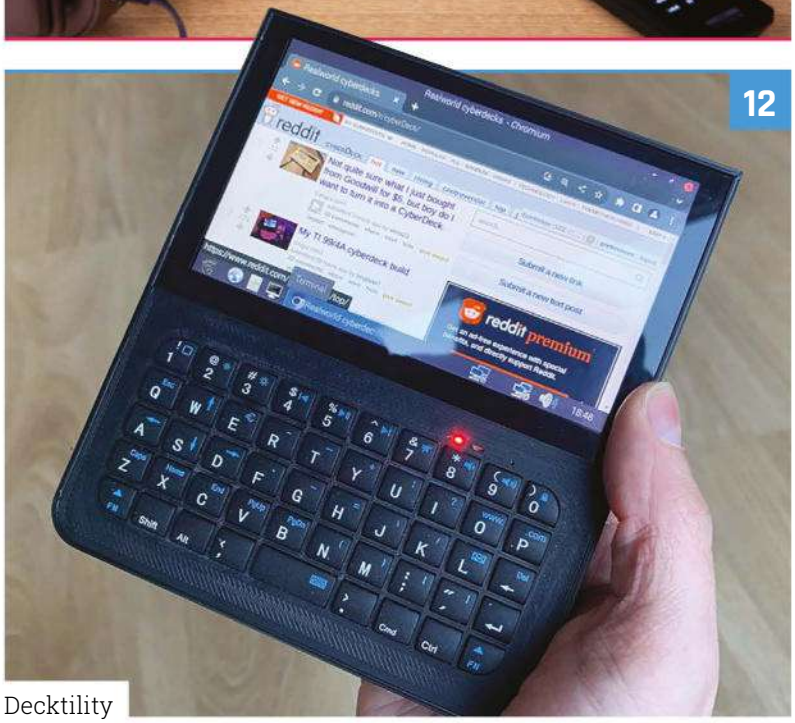
Star Wars diorama



Decktility

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Build a Pico LCD Game

Create a pomodoro timer

Technaxx TX-207

Liverpool Makerfest

WIN 1 OF 5 DESKPI PRO V2

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Paragraphica

A camera whose design is heavily influenced by a mole? **Nicola King** simply had to dig down...

MAKER

Bjørn Karmann

A senior experience and interaction designer based in Amsterdam, currently designing real and speculative futures at **oio.studio**.

bjoernkarmann.dk

Talented designer and artist Bjørn Karmann likes to push boundaries, and is heavily inspired by nature and "intelligences", as he explains. "I find intelligences, whether natural or digital, extremely fascinating. As a designer and artist, I try to use intelligence as part of my process – finding parallels or inspiration from both worlds can help us understand that there is much more to the world that we think or can see."

In particular, with the emergence of more AI tools that generate images, he's recently become interested in how AI 'sees' the world. "I found my self imagining these images as synthetic dreams of a being we can't understand," he shares.

Subterranean survival

Now throw into the mix inspiration from a book entitled *An Immense World: How Animal Senses Reveal the Hidden Realms Around Us* (Ed Yong), and Bjørn's thinking gets even more fascinating. The book explores how animals perceive the world differently from humans, and a specific story about the star-nosed mole resonated with him. The book describes "an intelligent hunter and explorer that navigates its world not through sight, but through touch. This creature, living in darkness, has developed a unique way of 'seeing' its environment using its star-shaped snout." This story illustrated to Bjørn "how different forms of intelligence perceive the world in ways that are almost unimaginable to us."

Challenge your perceptions

The fallout from all of this was the design and development of Paragraphica, a context-to-image camera that uses data, not light, to create images, and which offers "a different way of seeing the world, one that is based on data and AI interpretation rather than human perception." Bjørn feels that it's a tool that falls "somewhere between critical art and consumer product," allowing users to explore the 'dreams' of AI as he sees it, "providing a glimpse into a form of intelligence that is fundamentally different from our own."

Perhaps the most striking thing about the camera is the design of the cover on the front, where typically on a camera you'd find a lens, and we have the star-nosed mole to thank for that. Nature plays a key part in a lot of Bjørn's designs,

The three dials control the area radius, 'noise seed' (graininess), and 'guidance' for the AI (sharpness)

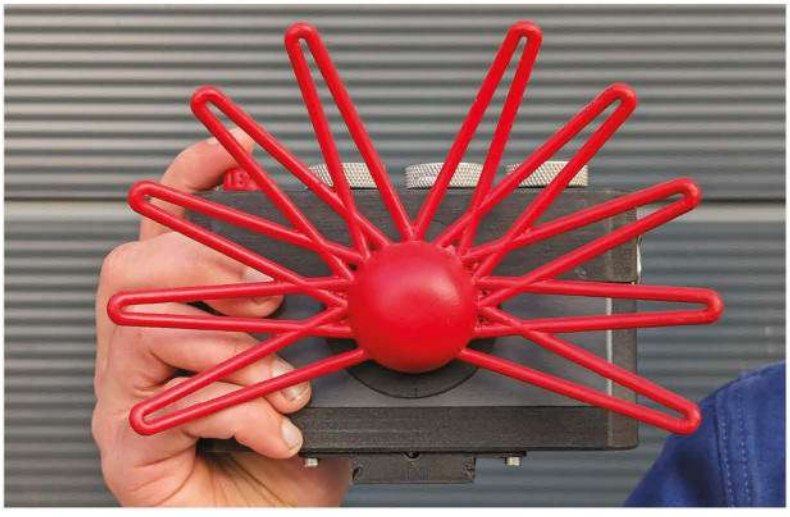
meters 10
seed 1
guide 100
52.382, 4.884
Pressing the red button triggers the camera to generate the image
The viewfinder shows the location data and the AI-generated image

Quick FACTS

- The development process took around six weeks
- Bjørn used a Prusa MK2 to 3D-print the camera shell…
- …in four parts, from two types of grey filament, in under an hour
- Bjørn's other Raspberry Pi projects include a "teachable parasite" (**magpi.cc/projectalias**)…
- …designed to give users more control over their smart assistants

and this small burrowing mammal's antenna-like snout was "the perfect inspiration for the camera." In addition, Bjørn wanted the front of the camera to evoke a "data collector", such as a radio antenna or satellite dish.

Bjørn's camera works by collecting data related to its location using open APIs, including OpenWeatherMap and Mapbox. This data is used to compose a paragraph (hence the name of the camera) that details a representation of the current place and moment, and this description is then used as the AI image prompt.



▲ The unique 3D-printed, mole-inspired design on the front brings to mind an antenna

meters 25
seed 0.1
guide 100
52.392, 4.877
A morning photo taken at Hembrugstraat 9-1, 1013 DW Amsterdam. The weather is few clouds with temperture of 15 degrees. The date is Wednesday the 24 May 2023. Near by there is a falafel, bus station, clinic, supermarket, coffee, .

▲ The 'paragraph' of data that the AI uses to generate the eventual image

"In a way, you can think of this process as filling in the blanks of a template paragraph," Bjørn suggests. "I then send this paragraph as a prompt for a text-to-image AI model to convert the paragraph into a 'photo'." Some of the resulting images have been surprisingly accurate, "but they never look like the real place – it helps to think of the resulting 'photo' as a data visualisation."

Bjørn wrote the software for the project, which uses a mix of a local Python script to simulate key presses, and a web application running in a browser. The web app was made using the Noodl platform, "and essentially gathers key parameters from the web, like weather, date, street name, time, and nearby places, and recomposes them into a template description."

Dial development

A Raspberry Pi 4 powers the device from within a 3D-printed shell. "Using a [Raspberry] Pi for the project gave me the freedom to prototype fast and explore some ideas for how it would work,"

▼ An example of using the camera. On the left is the real-life location, in the middle the 'paragraph' data, and on the right the AI generated image

A afternoon photo taken at Slingelandtstraat, 1051 CH The weather is sunny and 17 degrees. The date is Wednesday, 24 May, 2023 Near by there is a tank station and hardware store .

▲ Twiddling the dials on the top affects the location radius and the way the AI generates the image

Bjørn explains. "And I also had a Raspberry Pi 4 with a screen already attached to it laying in my workshop, so this felt like a good starting point."

As with most projects that we showcase, there were challenges to overcome during development, including 3D-modelling and 3D-printing the unique mole-inspired casing, and setting up the code and API pipeline for Raspberry Pi.

> A different way of 'seeing' the world, one that is based on data and AI interpretation rather than human perception

Bjørn has also been tweaking the dials on the camera, which enable the user to control the data and AI parameters, thus influencing the final 'photo'. "I have recently updated the two dials to affect the photo styles and years," he explains. "Changing the year the photo should be taken at is particularly fun, as you get to picture your street in the 1960s, or 2077 into the future."

View-finder

Bjørn describes the feedback received thus far as "mixed", with the area of AI igniting a range of reactions and opinions. Some people saw it as a product, but "struggled to connect it to a problem that needed to be solved." Others have understood the concept and absolutely loved it.

However, Bjørn feels that it "defiantly shows that the concept and manifestation hit a sensitive point." He's clear that his creation was intended to highlight and encourage discussion around AI perception, along with "the increasing use of AI in creative domains and technologies we use daily to capture reality. I think it did the job perfectly."

Visualising the scene

01 Bjørn is physically present in his chosen location, and his camera begins to collect the relevant data that it needs to create the eventual image.

```
A afternoon photo taken at
Westerpark NW. 102
The weather is sunny
and 22 degrees. The date is
Sunday, 21 May 2023.
Near by there is a park,
lake and city farm.
```

02 The viewfinder displays a real-time description of Bjørn's location, picking up on key pieces of information including the weather, the temperature, the time, and notable landmarks that are close by.

03 Bjørn adjusts his three dials, including the radius of the area he wants included. Pressing the red 'trigger' button, the camera creates its version of its surroundings, complete with, in this case, shadows, people, and greenery.

Decktility

Want to take Raspberry Pi OS out on the road with you? Then you need Ken Van Hoeylandt's handheld PC. **David Crookes** takes a look

MAKER

Ken Van Hoeylandt

Ken – aka ByteWelder – is a software developer who thanks his wife for being supportive of his crazy hobbies.

magpi.cc/decktility

When Ken Van Hoeylandt was growing up, computers were big, bulky machines. But by the time he was a teenager in the 1990s, they were shrinking fast, leaving Ken desperate to get his hands on some of them.

"I was attracted to the idea of being able to carry a computer with me all the time," he says. "I owned a Palm III and wrote some simple software for it, eventually giving it internet access over a serial cable at home. Later, I upgraded to a Sharp HC-4500; a Windows CE handheld PC with a colour screen and more capabilities."

Over the years, Ken's passion for handhelds has remained and he'd been keen to rekindle his love for them. "It's partially nostalgia and partially the freedom of having the power of a regular OS," he explains. "These days everyone has mobile phones and tablets, but they take away a lot of the control that you used to have."

How small?

Recently, after considering getting his hands on Clockwork's uConsole, a modular pocket-sized computer, he felt that building his own handheld was more challenging. Snapping up a Raspberry Pi Compute Module 4 (CM4), he also vowed to take advantage of its quad-core ARM Cortex-A72 processor by putting it at the heart of his own homemade device.

"I chose Raspberry Pi because of the support it has and how easy it is to use," Ken says, revealing he'd considered a Raspberry Pi Zero 2 W computer but felt he'd miss out on many connectivity options. "Raspberry Pi Zero 2 W would have resulted in a smaller handheld computer but, for a device that would be a daily driver, the user experience is the most important aspect above everything else."

To that end, Ken made some more crucial decisions. "I initially considered creating a foldable device, but making it thin enough to my liking would have been too hard for me to achieve," he explains. "Foldable devices require good hinges, and I suspect that it's very hard to make without expensive machinery like a micro mill setup." Instead, his device has the screen above the keyboard.

Key to success

The biggest challenge was the case design. Ken created the CAD files for the 3D-printed shell using Onshape, and he wanted it to be as compact as possible. He had to consider the layout of the components so that the wiring would be logical. "You don't want to put wires from one side of the case to the other and then back again," he adds. He also needed to consider cooling.

"There's limited space for a fan, and multiple components generate heat," he continues. "In other words: there are very few layout variations that work well, and you also have to take into account that everything needs to fit in place and be easy to assemble. When you make a change in a layout to improve wiring, it might affect airflow. It becomes a very interesting tech puzzle."

Even so, the casing works well. Time is now being spent making the keyboard better. "It's pretty bad," Ken confesses. "It's built like most TV remotes and you have to press it fairly hard to have it work consistently – fine for entering a Bash command or two, or perhaps a URL once or twice, but you don't want to use it to type lengthy emails or have a chat with someone."

It's why the next iteration of Decktility will have a fully custom keyboard with microswitches, but it's not the only changes being considered. "I'm currently using Raspberry Pi OS, but I might tinker with Kali Linux or Parrot OS in the future," Ken says. "I've also been curious about software-defined radio (for example, RTL-SDR), so I might play with that at some point too."

To ensure good balance, the screen and two 18650 batteries are on different sides of the device
Decktility uses the BigTreeTech Raspberry Pad 5 IPS touchscreen, outputting a resolution of 800×480 px
A new fully custom keyboard with microswitches will be added to ensure more reliability and faster typing

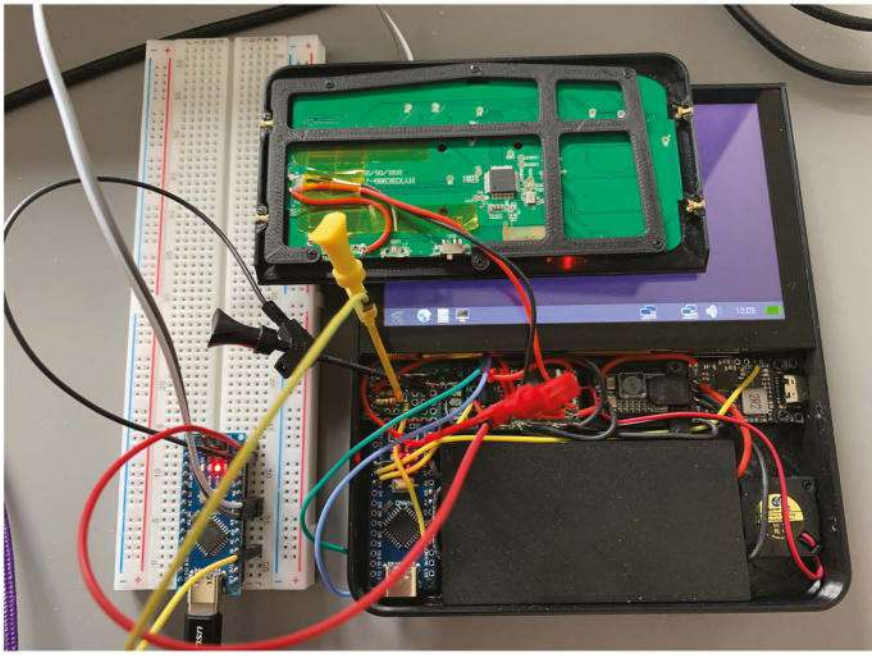
Quick FACTS

- The build took just 100 hours to complete
- Most time was spent designing the case
- The batteries provide up to six hours of power
- An Arduino Nano helps prevent battery drain
- Replicating the project would cost about €300

▼ A lot of work went in to ensuring all of the components would fit snugly inside the device

> For a device that would be a daily driver, the user experience is the most important aspect

▲ Later down the line, Ken may attempt to create an aluminium CNC-milled case for Decktility



Mona Lisa Fluid Painting

A creative way of demonstrating the capabilities of microfluidic biosensors, captured on a Raspberry Pi HQ Camera, caught the eye of **Rosie Hattersley**

MAKER

Yuksel Temiz

Microsystem engineer Yuksel impressed people so much with his Raspberry Pi Lego microscope, he has since set up a company developing 3D microscopes: **microqubic.com**.

magpi.cc/monalisa

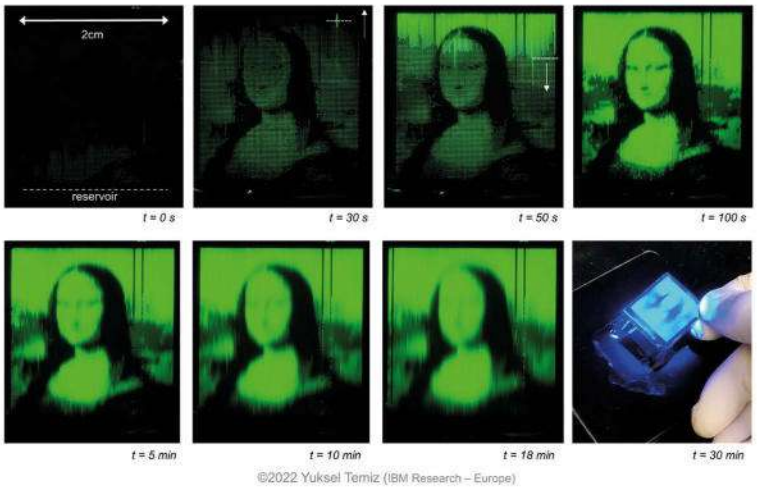
Big, brash ideas and enormous displays gain attention, whereas tiny but significant products can be far harder to convey. After helping develop a crucial microfluidic-based biosensor system for use in microscopic research at IBM Zurich (**magpi.cc/precisiondiagnostics**), microsystem engineer, and keen YouTuber, Yuksel Temiz and Polytechnique Montréal researchers hit on the idea of using an iconic artwork to show off its possibilities.

The Mona Lisa Fluid Painting project showcases a new microfluidic architecture that allows local and highly parallel dissolution of biochemical reagents in volumes as low as two nanolitres per spot. The image was created from just five microlitres of water 'painted' on a 2cm square microfluidic chip. The microfluidic architecture has potential applications in healthcare diagnostics and life sciences, "opening up new possibilities in studying kinetics and interactions of chemicals in nanolitre volumes and in high-throughput."

Yuksel spent nearly ten years working at IBM's labs in Zurich, and says, "In our research, we always needed compact optical, electrical, and mechanical peripherals to read out and control our biosensors. For me, Raspberry Pi has always been the easiest way to implement a minimum viable product, especially for imaging applications."

When it came to showing off the incredibly tiny droplets, Raspberry Pi soon became the obvious route to take, enabling them to create an impactful showcase to go alongside a press release about their work without investing too much time and money. "Raspberry Pi allowed me to test and optimise the setup very quickly with minimal investment," enthuses Yuksel.

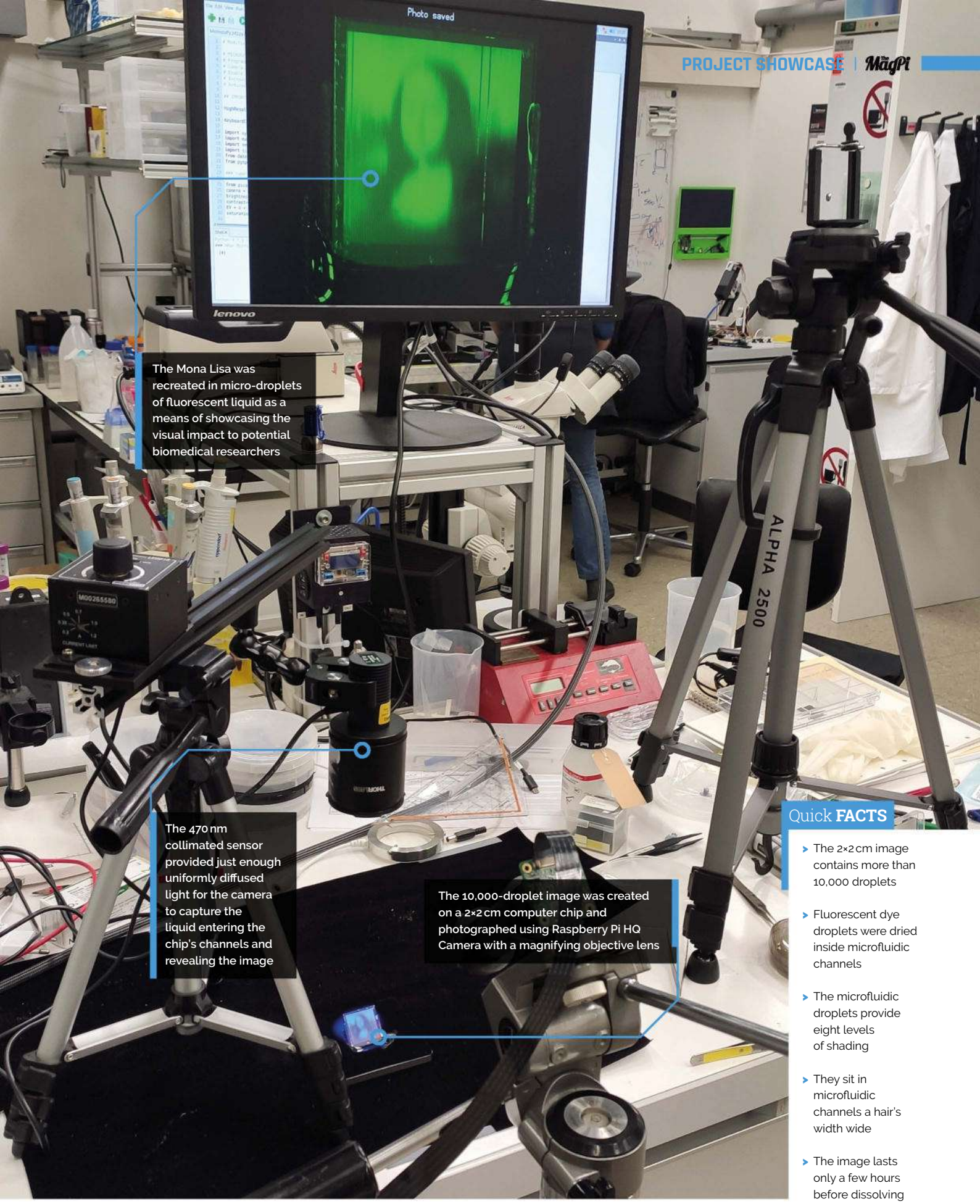
"Coding is just a hobby for me. But the thing I like about Raspberry Pi is you don't need to be a professional coder to build functional systems."



Stills captured using Raspberry Pi HQ Camera showing the Mona Lisa image being created

Camera conundrum

More than 10,000 droplets of fluorescent dye in eight different shades were spotted and dried inside microfluidic channels to generate the Mona Lisa image. Once the channels for the droplets had been engraved, the top of the chip was sealed and liquid applied – a process that took just under two minutes. It was important that the dyes were



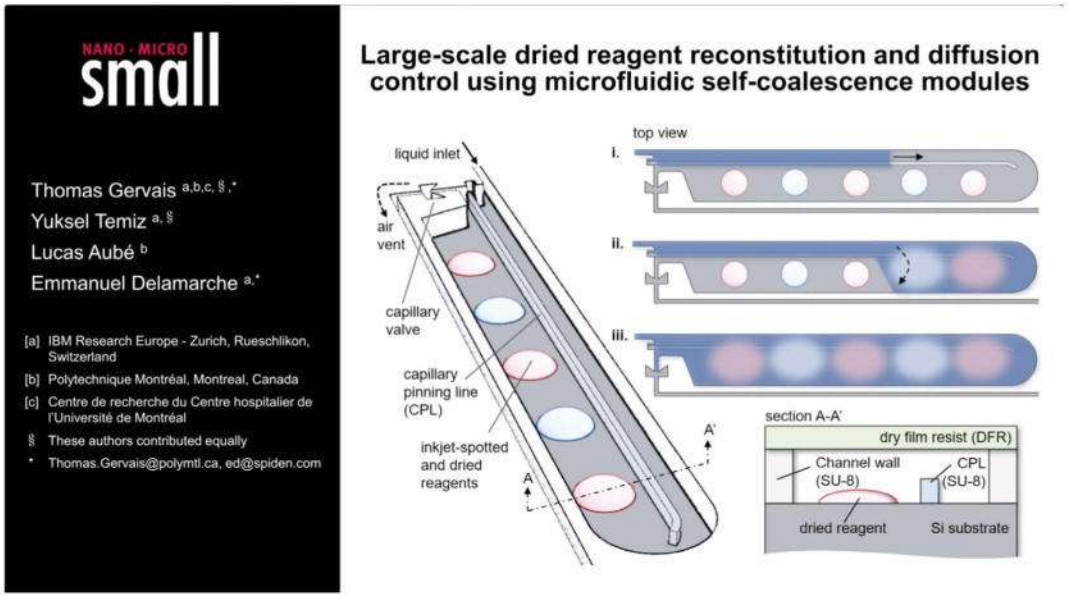
The Mona Lisa was recreated in micro-droplets of fluorescent liquid as a means of showcasing the visual impact to potential biomedical researchers

The 470 nm collimated sensor provided just enough uniformly diffused light for the camera to capture the liquid entering the chip's channels and revealing the image

The 10,000-droplet image was created on a 2×2 cm computer chip and photographed using Raspberry Pi HQ Camera with a magnifying objective lens

Quick **FACTS**

- The 2×2 cm image contains more than 10,000 droplets
- Fluorescent dye droplets were dried inside microfluidic channels
- The microfluidic droplets provide eight levels of shading
- They sit in microfluidic channels a hair's width wide
- The image lasts only a few hours before dissolving



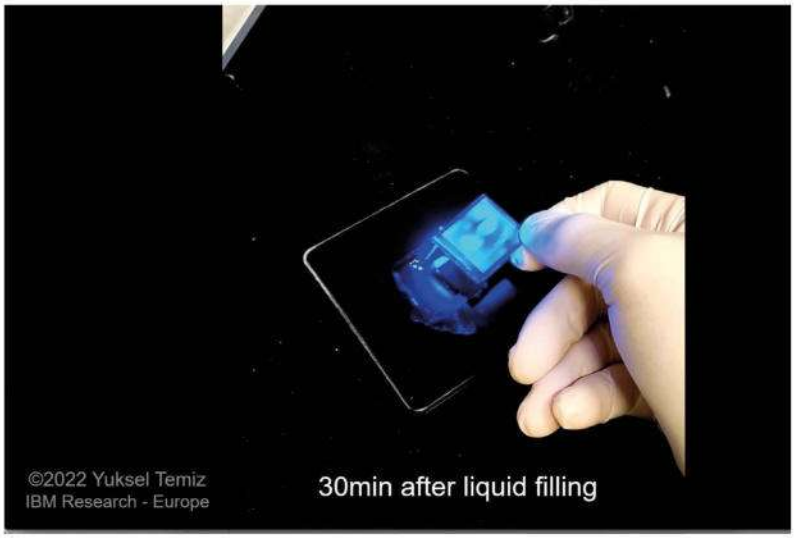
Yuksel and colleagues presented a guide to using the microfluidic sensor modules as part of their research paper

> The thing I like about Raspberry Pi is you don't need to be a professional coder to build functional systems

dissolved locally without dragging them. Having painstakingly planned the image, it then faded out after a few hours as the droplets diffused. However, the fluorescence image was captured for posterity, having been filmed using a custom-built setup based on Raspberry Pi's HQ Camera. Given the impermanence of the image, it was critical that the camera captured everything first time, as there wouldn't be a chance to reset and repeat things if they went wrong.

Yuksel explains the difficulty of videoing the water filling the channels and revealing the portrait: the imaging area was too large for the field-of-view of their high-end fluorescence microscopes, while the channels and individual droplets of fluorescent dye were too small for an imaging setup with an SLR camera to be considered. "Image stitching was not an option either because the liquid filling was too fast for the

The YouTube video shows the image being created in real-time



▲ The image lasted just long enough for Raspberry Pi HQ camera to capture it, then began diffusing so the colours merged

motorised stage of our fluorescence microscope." He realised an imaging setup using Raspberry Pi's HQ Camera would be ideal because he could easily attach a C-mount magnifying objective lens and fix the camera to a tripod.

Building blocks

Fortunately, Yuksel already had a number of Raspberry Pis in his lab, and had gained plenty of experience of microscopy while designing and building a very impressive Raspberry Pi-based LEGO microscope a couple of years previously: **magpi.cc/hqmicroscope**.

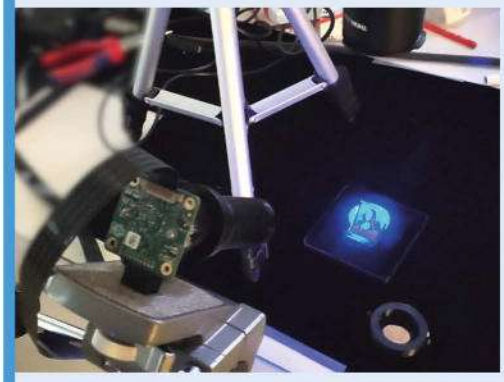
For the Mona Lisa water painting project, he custom-designed and 3D-printed an adapter for the emission filter to be placed in front of the objective lens for fluorescence imaging. Illuminating the sample was tricky, says Yuksel, because the area was too large for light sources used in classical microscopes, and it had required a specific wavelength for the fluorescent dye. Fortunately, he had a collimated 470 nm LED light from an earlier project, which was able to uniformly illuminate the sample.

Photography-wise, Yuksel had also cut his teeth on a prior Raspberry Pi project: a stop-motion project showing a 3D model boat he'd made in action: **magpi.cc/stopmotionboat**.

Nonetheless, he was taking no chances, and put together a standby chip just in case. After all, the chip couldn't be reused once the liquid was applied, so there was just one chance to capture the image-creation process. Thankfully, everything went without a hitch, thanks to his meticulous planning.

Microscopic art

01 Microscopic channels to hold 10,000 drops of dried fluorescent chemicals were etched onto a 2×2 cm chip. Eight shades were used to create the Mona Lisa image.



02 A Raspberry Pi HQ Camera was mounted on a tripod, a microscope filter attached, and the whole setup trained on the microscopic chip. Many camera recording checks were made because there would be no second chances.

03 Filming began as liquid was slowly but steadily introduced in a controlled manner, where it dissolved the spotted dyes. The effect was visible for a few hours before diffusion caused the colours to bleed into each other and the spectacle was over.

Star Wars diorama

Become a new hope for a galaxy far, far away by recreating an iconic scene from *Star Wars*. **Rob Zwetsloot** checks out the information stored in this R2-unit

MAKER

Wayne Chan

Research computer analyst with the Centre for Earth Observation Science, a climatological research centre. Also a maker, historical researcher, and retrocomputing enthusiast

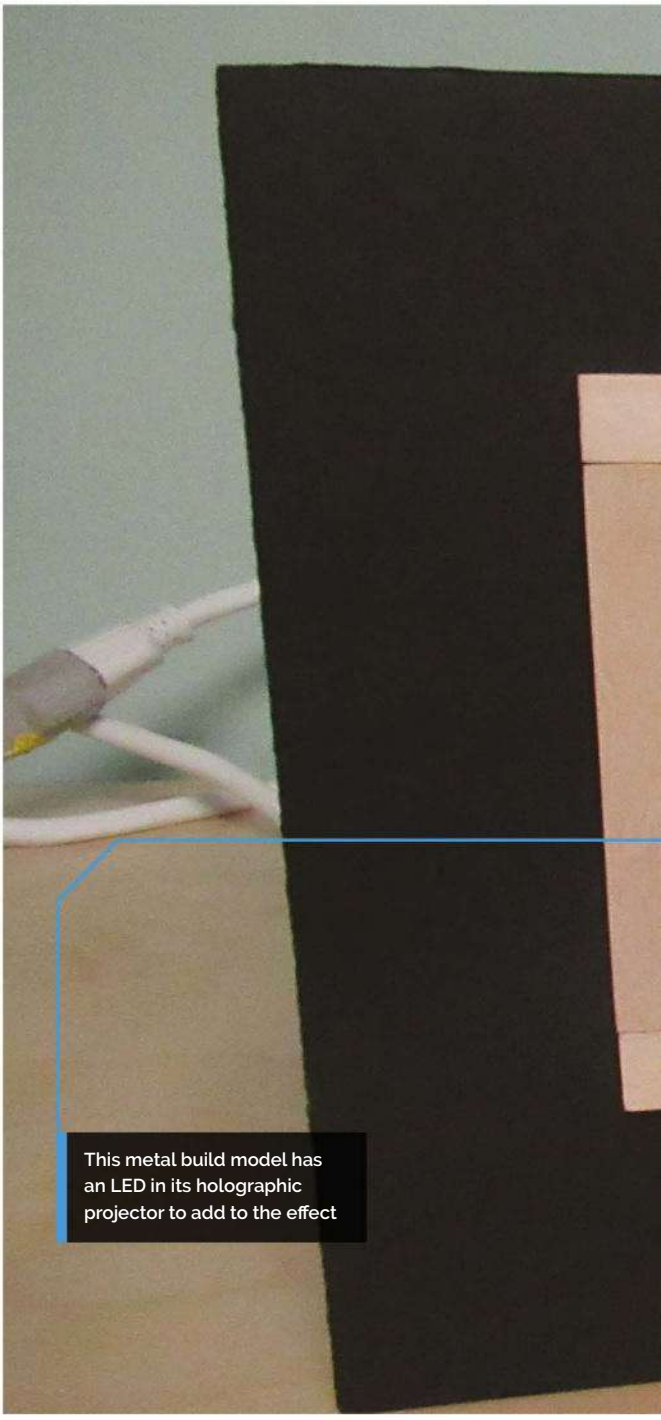
hackaday.io/cmdln

"**Help me, Obi-Wan Kenobi.** You're my only hope" pleaded Princess Leia in a hologram message to the old Jedi Master, an iconic *Star Wars* line from one of the most important films of all time, called back to in many films, books, and games in the franchise. This scene has been faithfully recreated by Wayne Chan, previously featured in *The MagPi* with his entry/exit notifier in issue 117 (**magpi.cc/117**), using some very neat effects.

"During the holiday season last year, I bought a metal model kit of R2-D2 as a gift for a friend who was a *Star Wars* fan," Wayne tells us. "However, after thinking about it, I realized that she wasn't very handy and would likely have trouble assembling the kit, so I decided to assemble it myself and then give it to her. It took more time than I had anticipated, though, and I ended up having to give her something else in time for Christmas." This delay gave Wayne a bit more time to think up a better gift using R2-D2.

"My intention was then to give the model to her on some other occasion," Wayne continues. "However, once I had R2-D2 built, it seemed like the model by itself wasn't enough, so I decided to create a diorama around it. After brainstorming a few ideas, I settled on the iconic scene from *Star Wars: Episode IV: A New Hope* where Artoo projects a hologram of Princess Leia. I knew I could probably use the old Pepper's Ghost illusion to emulate the holographic effect."

We've talked about Pepper's Ghost illusions in the past – it's an old, yet very effective, practical optical illusion where a scene out of view of the observer is reflected onto a sheet of clear glass (or similar) that the audience can see. It's used in theme parks, concerts, teleprompters, and much more.



This metal build model has an LED in its holographic projector to add to the effect

Do or do not

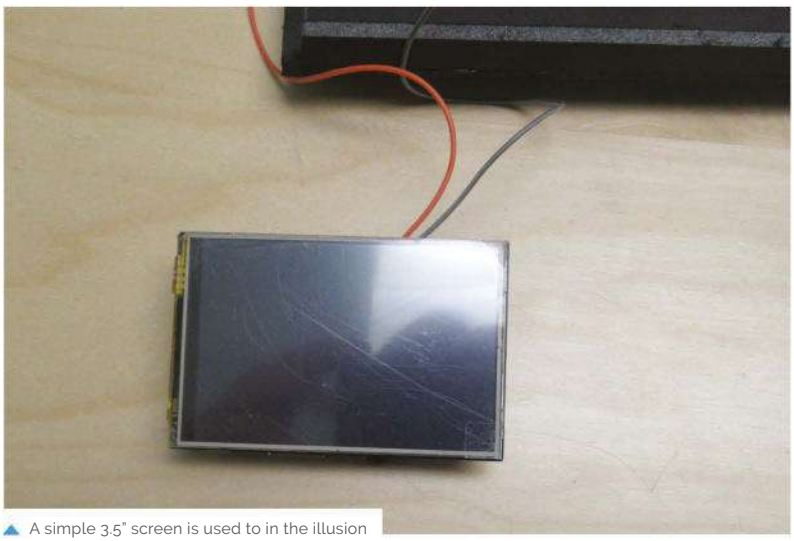
Wayne decided to go ahead using a Raspberry Pi 3A+ he had lying around and connecting a 3.5" LCD screen – although he had to fight a bit of GPIO space for everything else, it all came together nicely.

A GPIO button on top turns off the system

Using an optical illusion, Leia can be seen as a hologram on the table

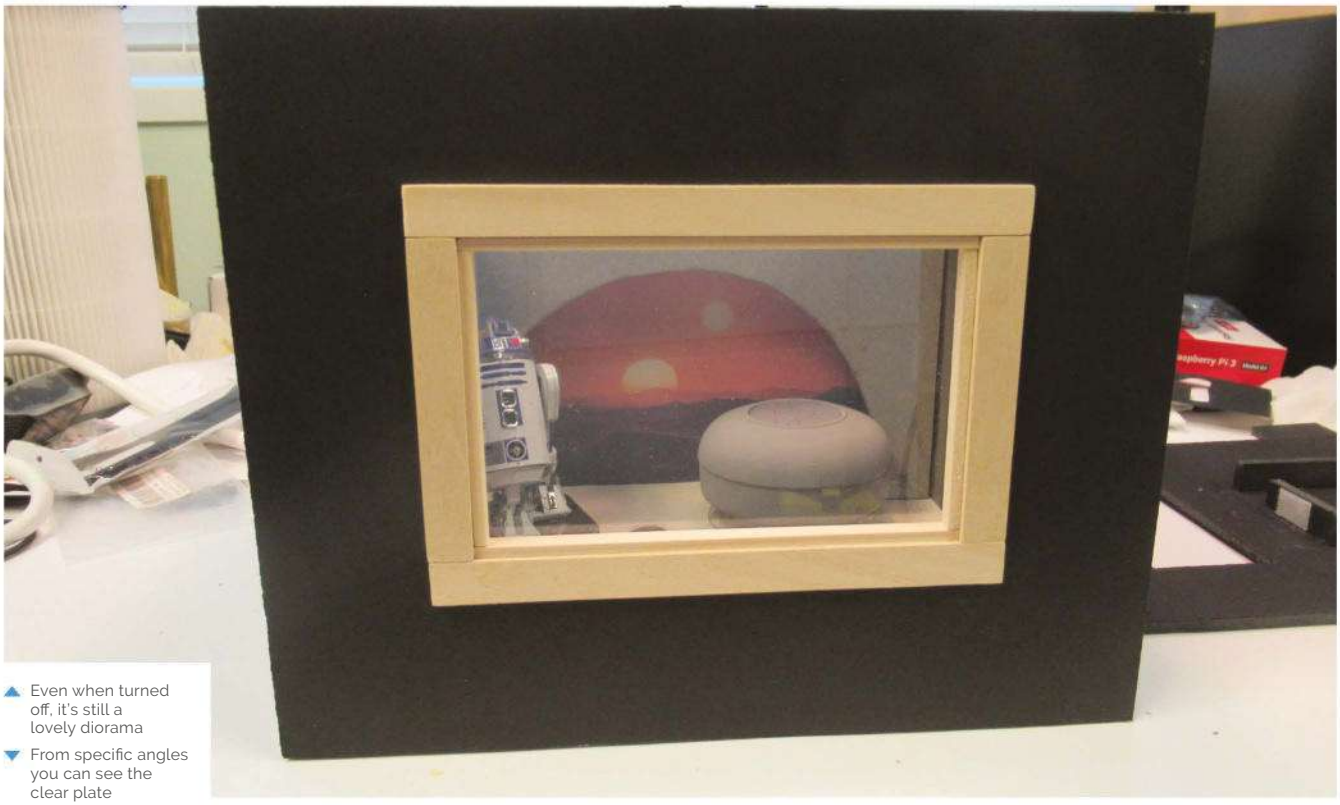
Quick FACTS

- It uses a custom video of Leia's message...
- ... recreated frame-by-frame by Rob Meyer on YouTube: **magpi.cc/hololeia**
- The R2-D2 model is from the Metal Earth Premium Series
- Building the R2-D2 model was the hardest part of the build for Wayne
- Originally a window at the top of the box provided light, but it messed with the effect



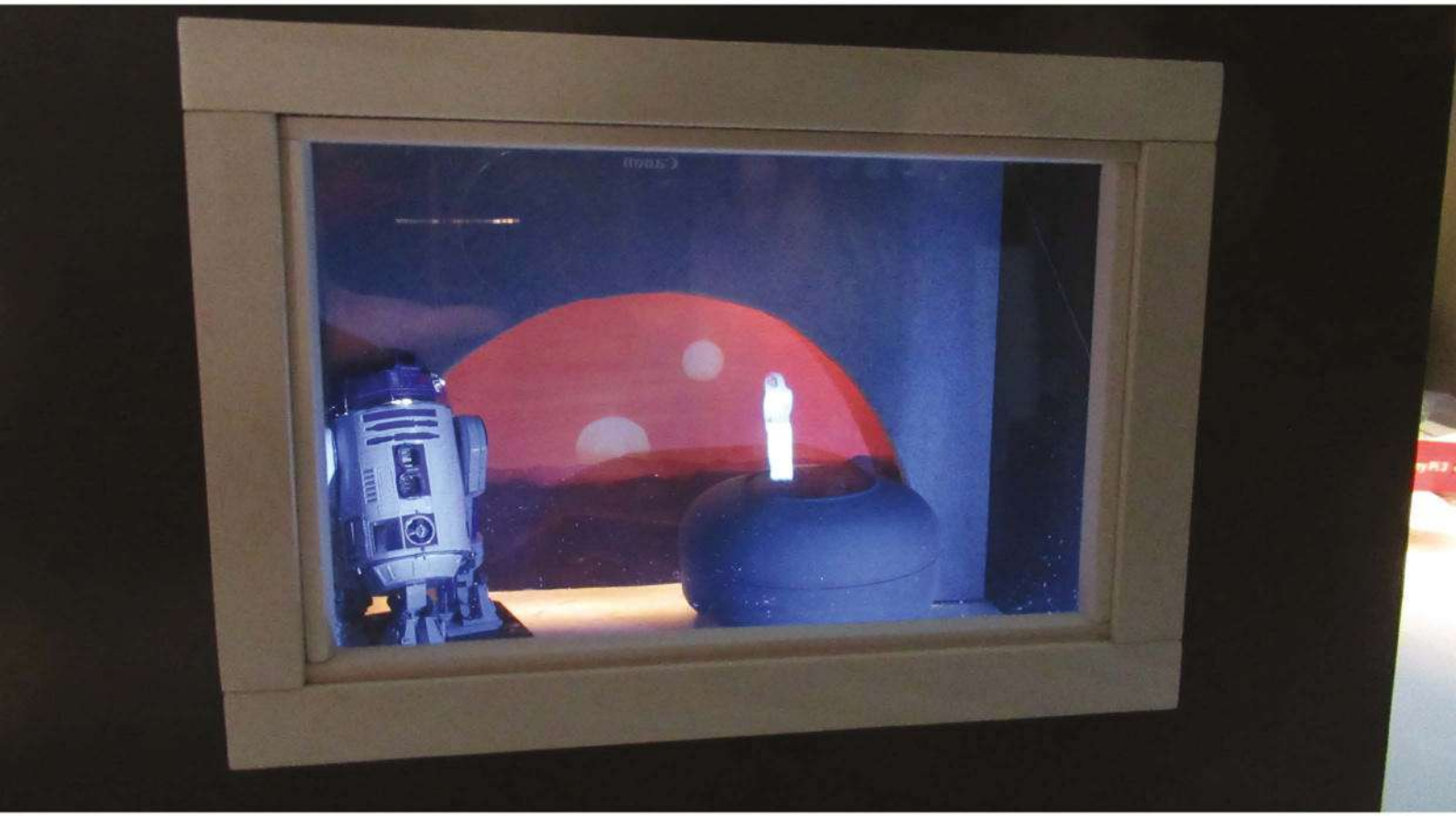
▲ A simple 3.5" screen is used to in the illusion

"The box is made from black foamcore board," Wayne explains. "A sheet of clear acrylic is set at a 45 degree angle in the box... A video of Princess Leia's holographic message is played on the screen and reflected by the acrylic sheet to look like she is standing on the table. Inside the R2-D2 model, there is a white LED that's located behind the holoprojector port in R2-D2's head. This simulates the light coming from the projector when R2 is



▲ Even when turned off, it's still a lovely diorama

▼ From specific angles you can see the clear plate



▲ The box is somewhat conspicuous, but still quite small

displaying the hologram. Another LED was placed near the front of the diorama to provide some illumination to the scene. Both LEDs are powered by USB."

With most of the visual part sorted, Wayne then looked at speakers so the message could actually be played.

"To hear Leia's message, I found a speaker at a thrift shop that vaguely resembled the round table in Obi-Wan's house," Wayne says. "It was originally a Bluetooth speaker, but I didn't want

> A video of Princess Leia's holographic message is played on the screen and reflected by the acrylic sheet to look like she is standing on the table

to worry about losing the pairing or having to recharge the lithium-ion battery all the time, so I gutted the internals and replaced them with a mini audio amplifier board, which I wired to the raw speaker. The audio input came from the 3.5mm jack on Raspberry Pi, and power was supplied through USB instead of a battery."

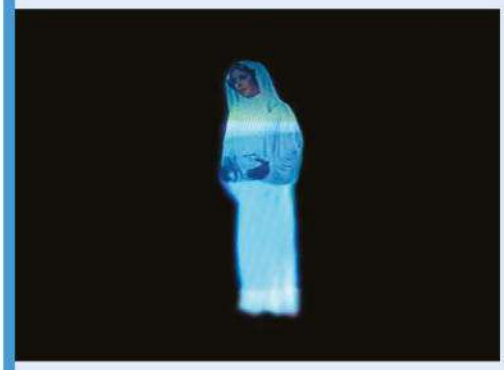
Token of goodwill

Although not quite finished, Wayne was able to gift it... briefly.

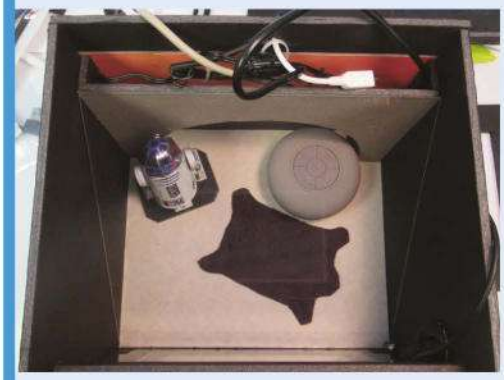
"I showed it to my friend on Star Wars Day (May 4)," Wayne tells us. "She loved it and said it was the best gift she has ever received. She even hugged it! I refused to let her have it, though, because I wasn't quite finished with it yet. When (if?) my friend finally receives the diorama, I am told that it will have pride of place on the main shelf of her new entertainment unit. She's getting a little impatient, since I keep finding things to add to it!"

We wish Wayne good luck, and may the Force be with him.

Diorama detail



01 You'll need a specific video of Princess Leia giving her speech from a single angle, and in full, for the diorama.



02 A piece of clear acrylic is placed at a 45 degree angle to the top of the box so that it can reflect the video onto the speaker/table.

03 The electronics are hidden inside the lid, including the screen with the Leia message playing. The speaker is plugged into the USB hub to cut down on interference.

Pipistrelle Bat Detector

Watching wildlife can be highly rewarding. This bat detector puts Pi Zero to good effect, discerning species by their calls. By **Rosie Hattersley**

MAKER

Phil Atkin

Phil began coding in 1980 and often uses it for high-end audio and acoustic projects.

omenie.com

What bats do in the shadows is quite mysterious, given the challenge of watching the speedy creatures as they flit silently by at dusk. However, their barely-audible-to-humans ultrasonic squeaks can tell those in the know plenty about their movements, moods, and motivations.

Unfortunately, bat detectors cost anywhere from £120 up to £1500+, and devices in the sub-£200 price range are technologically rudimentary, warns Pipistrelle Bat Detector maker Philip Atkin. "They operate like a transistor radio, requiring the user to twiddle a knob to tune into a specific frequency (i.e. a specific bat species), which can lead to frustration as you can miss bats because you are not tuned into the right species." As the Bat Conservation Trust shows, there are many more species even here in the UK than you might realise: **magpi.cc/ukbats**.

Phil set about designing a method of detecting bats that did not fall foul of frequency issues. His several decades of coding experience and, in particular, his expertise in music synthesis, proved ideal when it came to designing a low-cost device based around Raspberry Pi Pico.

Tuning in

The first challenge was working out whether there were any bats around. Bats echolocate using ultrasonic frequencies, well beyond human range, but they can't be heard and are hard to see: "uniquely for mammals, you need technology to detect and study bats," says Phil. His approach was to have Pico's sensors scan all the frequencies and seek out the strongest ultrasonic signal. It took him just three weeks to design a Pico-based bat detector that included an operational amp (one which amplifies weak signals), an ultrasonic microphone, a button, and enough software to detect bats and perform speech synthesis.

However, the working prototype board was "an ugly mess and too fragile to take out on surveys," says Phil, who then turned it into both a printed circuit board and an ultrasonic recorder, adding the ability to record 384kHz/16-bit WAV files to an SD card. This extended the project's usefulness and meant he could move on to perfecting the surprisingly challenging ultrasonic recording features. Not one to shy away from a technical challenge, Phil chose 128-bit FFTs (fast Fourier transforms) to ensure even the highest frequency bats could be detected. Pico offers exceptional functionality for its size. "Its rich feature set and programmable GPIOs meant that I needed to add the bare minimum of hardware to the design beyond the Pico," Phil comments "while offering a combination of low cost, low power consumption and the ability to handle 100% duty cycles when processing 128bit FFTs." This efficiency means Pipistrelle can be used as a passive recorder for four or five nights, "sleeping during the day, listening during the dark, and triggering recordings whenever bat candidate sounds are heard." These, he likens to music.

Using AudioMoth as a real time clock, the Pipistrelle device can automatically detect bats while unattended, as well as flash when one is detected during a bat walk

Pico offers high-sensitivity recording and 'speech-based' species recognition, recording each bat's beautiful calls and speech

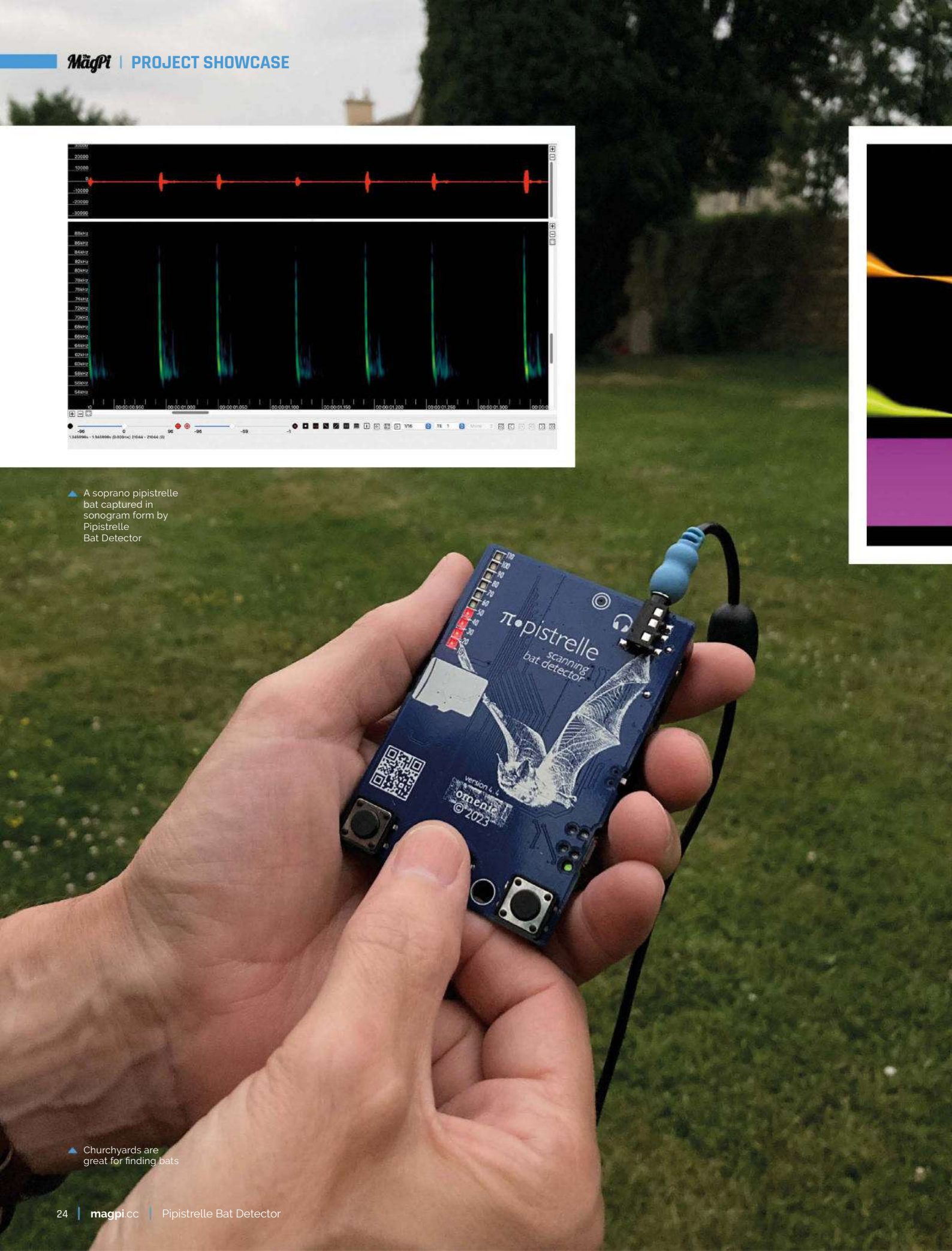
This Pico-based self-assembly Pipistrelle bat detector kit can detect echolocation bat calls across multiple frequencies

Quick FACTS

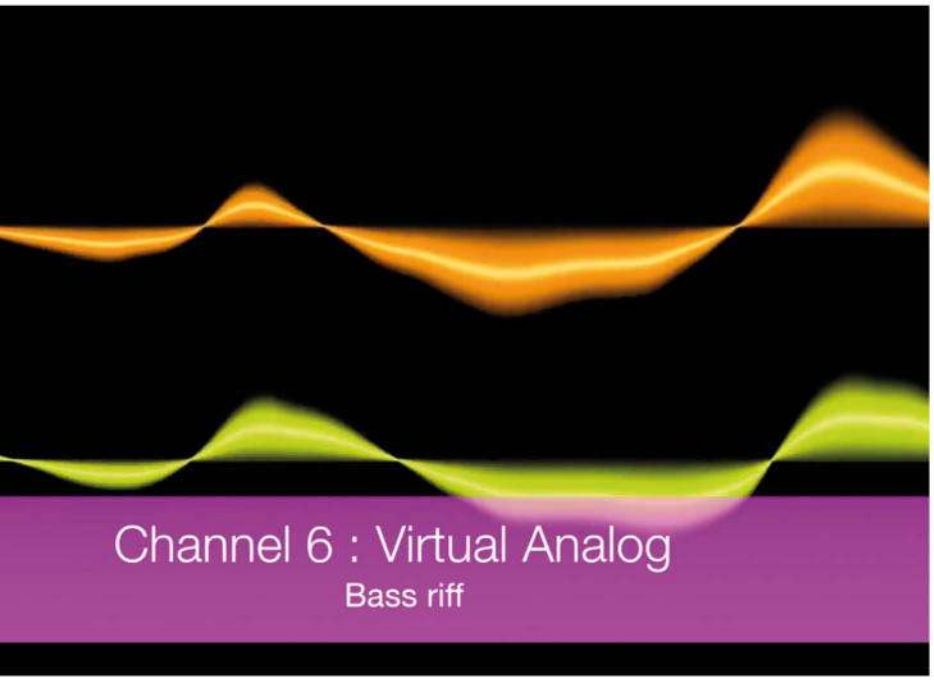
- Phil's interest in bat detecting began in church
- The Bats in Churches project used expensive kit
- So he learned CAD design to create a better option
- Using skills from his high-end *Doctor Who* audio project
- Which also used Raspberry Pi Pico of course: **magpi.cc/drwhopico**

▲ The Bat Conservation Trust helps you identify bat species. This beauty is a Lesser Horseshoe

▲ A soprano pipistrelle bat captured in sonogram form by Pipistrelle Bat Detector



▲ Churchyards are great for finding bats



▲ Phil's previous project used a Pico to recreate the *Doctor Who* theme tune

"To hear the bats' true calls – the bird-like whistles, the peeps, chirps, and high-pitched screams of the Horseshoes – is remarkable."

Double duty

Two years on from his original prototype, there are now three models: BatWalk, a detector to take on bat walks; PippyG ultrasonic recorder; and Pipistrelle itself, which offers both functions.

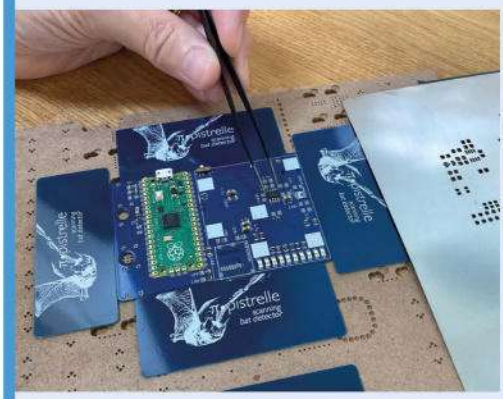
> "Uniquely for mammals, you need technology to detect and study bats"

The recorder can either be used manually for on-demand recording, or set to record overnight whenever a bat call is heard. "Overnight recording lets me shut down more of the Pico to get cleaner recordings," says Phil, an audio purist keen to banish even the slightest operational sounds of the electronics caused by the need to write to the SD card. Each of these can be bought via his Omenie website, and integrated into your bat detection project. A full bill of materials and instructions are provided.

Though he continues to tinker with the audio, Phil finally feels the project is mature enough for someone to potentially create an Android version of it (since the software is open-source) and sees its further potential for studying other ultrasonic creatures, listing cetacean research, since dolphins use ultrasound, along with small mammals and insects.

Is a bat about?

01 Build a solder stencil rig and carefully tape it up, ready to fit the Pipistrelle circuit board once you've snapped them off their cardboard backing.



02 Align the Pipistrelle PCB parts around the microphone pads and SD card and attach Raspberry Pi Pico using solder paste. Connect and power up to check Pico's connections.

03 Add a battery pack for portable bat detecting, using sticky pads to help secure it. Happy batwalking!

Flight tracker with weather

When Adam Paulson wanted to recreate a flight tracker, he decided it needed to spread its wings, as **David Crookes** explains

MAKER

Adam Paulson

Adam works for the airlines and he has been around airplanes almost his entire life. He lives in a major city so it's easy to spot planes.

magpi.cc/planetrackerrgbpi

There are two key reasons why showcasing projects is important. First, it gives makers a chance to show what they and Raspberry Pi are capable of achieving. Second, it inspires others to try their hand at their own project, sometimes bettering what came before.

Adam Paulson's project is a good example of the latter. Inspired by The Fridge Flight Tracker, created by a Reddit user going by the name Myniceaccount, it goes further than simply marking where planes are in the sky. Adam's version provides a three-day weather forecast and displays the temperature. It's open-source, too, allowing people to make their own improvements.

"I originally saw someone post a flight tracker using an Arduino but it only displayed overhead flights – when there were no planes, it was a blank screen," Adam explains. "Myniceaccount posted his own project in the comments on Reddit and it included a clock and a flight tracker using Raspberry Pi, so I followed the instructions and built one.

"Afterwards, I kept looking at the empty space and thinking it could be utilised so much more, especially since it was already pulling data from a weather website and flight tracking website. With some help with the coding, more functions were slowly added." The result is a constantly useful device.

▼ The device pulls in the current temperature every ten minutes and issues a forecast every hour

Raspberry Pi in the sky

Rather than use a screen, the project incorporates a 64×32 RGB matrix panel. "I liked the way it looks," Adam says. "It's very low key and old school while being easier to read (I think). If you had a screen, you could add more information, but it would become too cluttered. This one is simple and to the point."

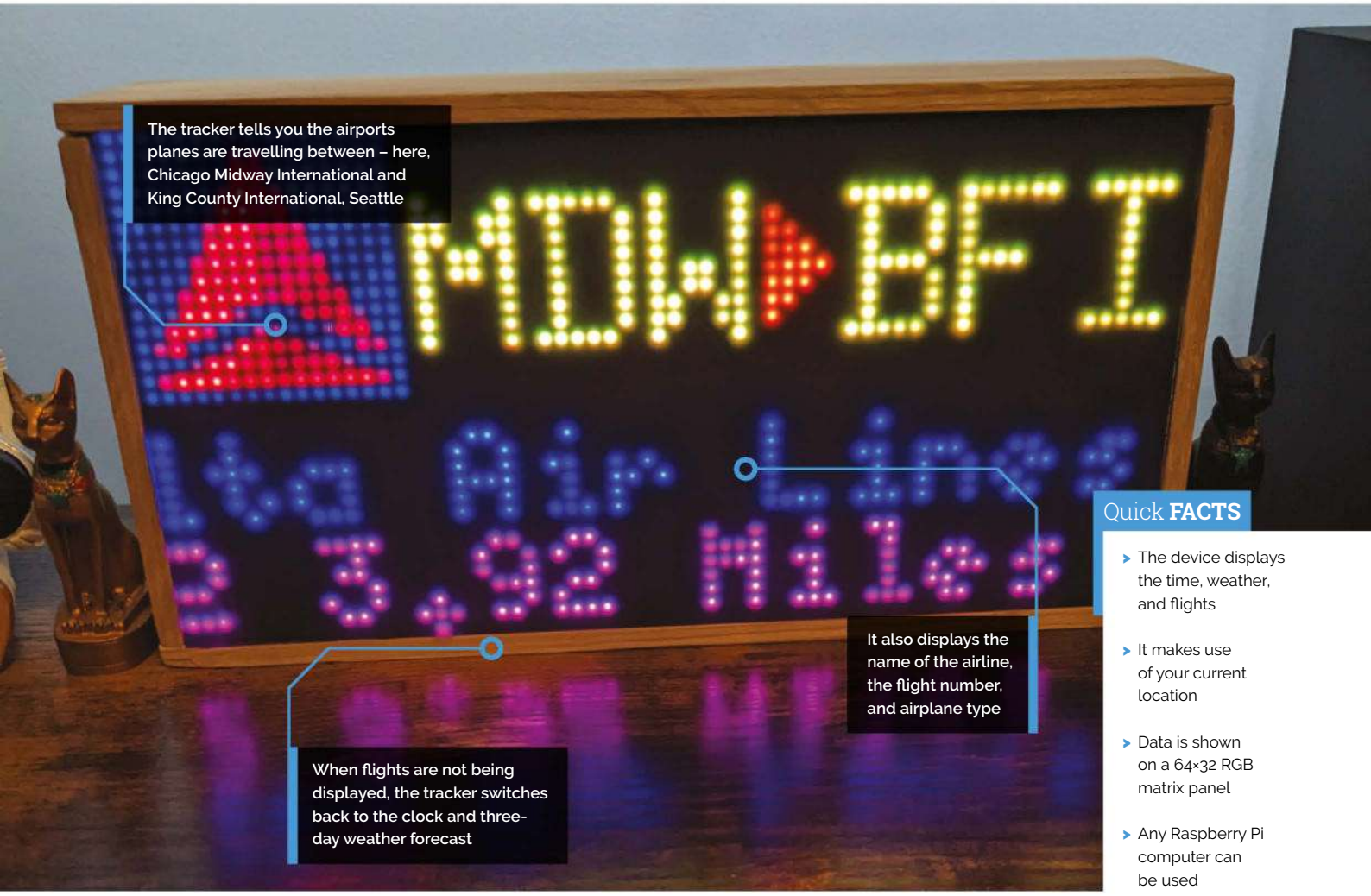
An Adafruit Bonnet controls the panel, which is covered with black tinted acrylic and housed within a case. Once the casing was cut and glued together, Adam set up his Raspberry Pi 3A+ computer and began working on the software.

"Originally the display showed the time, date, and current temperature on the main screen and the flight route, call sign, and aircraft on the other," Adam continues. "I had the idea to add a weather forecast on the main screen and to add the airline logo, distance, and direction on the flight screen. I just needed help from someone who knew Python to put it all together.

"I found someone, but he didn't have the setup to test it, so we spent weeks going back and forth – him sending code and me running it, then sending error reports or feedback on what was working and wasn't working." After making the time and date smaller, Adam dabbled with a four-day forecast only to realise three-digit temperatures messed up the screen layout. He chopped a day away.

Is it a bird?

Flight tracking remains a very important part of the project. Adam is a keen plane spotter and a device to aid his hobby was his primary motivation. To ensure accuracy, flight information is sourced from FlightRadarAPI.


MDW BFI
3,92 Miles
The tracker tells you the airports planes are travelling between – here, Chicago Midway International and King County International, Seattle
It also displays the name of the airline, the flight number, and airplane type
When flights are not being displayed, the tracker switches back to the clock and three-day weather forecast

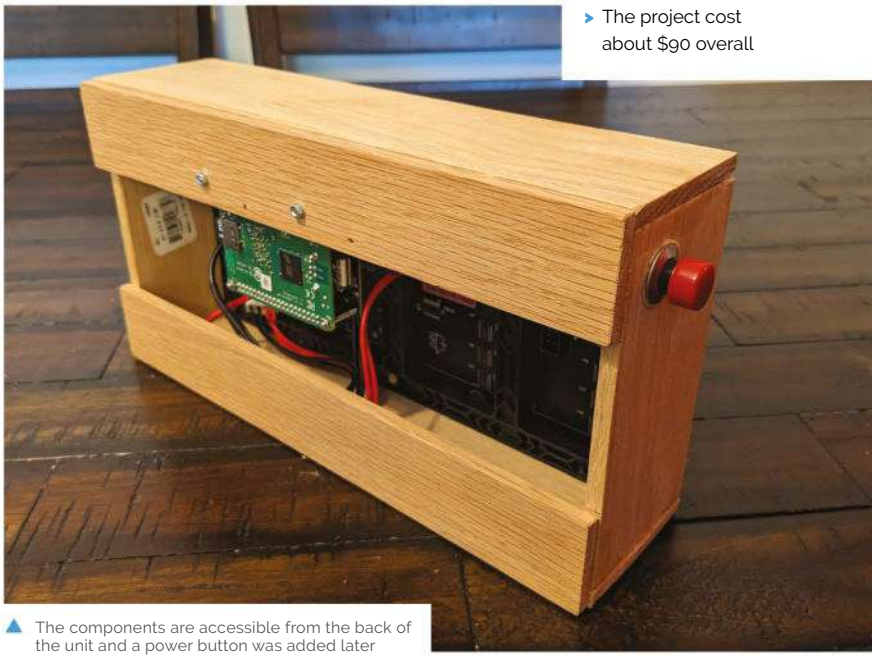
Quick FACTS

- The device displays the time, weather, and flights
- It makes use of your current location
- Data is shown on a 64×32 RGB matrix panel
- Any Raspberry Pi computer can be used
- The project cost about $90 overall

> I kept looking at the empty space and thinking it could be utilised so much more

"When a plane enters a predetermined 'box' made from two lat/long points in the config file along with a minimum altitude, it pulls the flight info and lat/long of the plane and compares it to the lat/long of your location," Adam explains. "As the plane flies through the box, it updates its distance and direction until it's out of the box, where it switches back to the clock and weather."

The device now takes pride of place beneath Adam's TV, allowing him to quickly view its information. "With this device I can hear a plane outside and I can discover what it is," Adam says. "This project was also my first involving an actual display and casing so it was definitely a new experience for me."



▲ The components are accessible from the back of the unit and a power button was added later

Raspberry Pi-Controlled Automatic Phone Ring Killer

Landline phone interrupting your beauty sleep? This maker tasked Raspberry Pi to keep his silent during the night. **Rob Zwetsloot** gives him a buzz

MAKER

Barry Mead

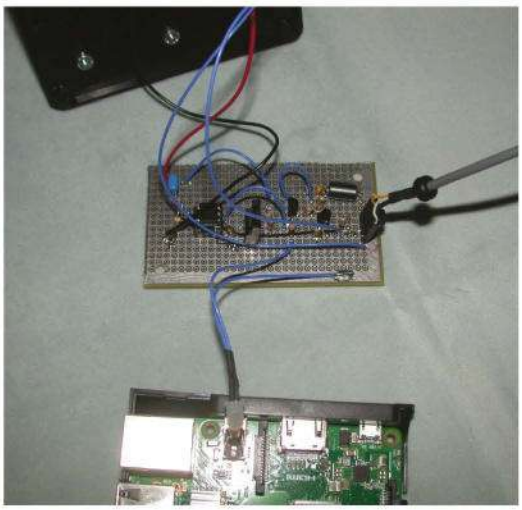
Retired electronics engineer, and software developer and current hobbyist maker, who created the first check-as-you-type spell checker.

magpi.cc/github

If you've ever wondered why millennials don't like to answer the phone, one of the reasons is that there's just a lot of people trying to scam you. They also call at all hours of the day, so we end up putting our phones on silent or just unplugging our landlines. Not every generation is like this though, and people like Barry Mead had to get creative.

"I built a fun little project which automatically silences my landline telephone ringers throughout the house at times when I want to sleep," Barry tells us. He'd seen a similar project on Instructables (**magpi.cc/ringkiller**) and decided to add a Raspberry Pi to the mix to allow for better control.

"I had designed a few other projects using Raspberry Pi, so I had extra Raspberry Pi's laying around," Barry explains. "[I] decided to put my extra Raspberry Pi 3B+ to good use as the +5V power source [of the] automatic timer for the phone ring killer circuit."



The circuit detects incoming calls and sends the correct signal to the operator to stop the ring

In the lab

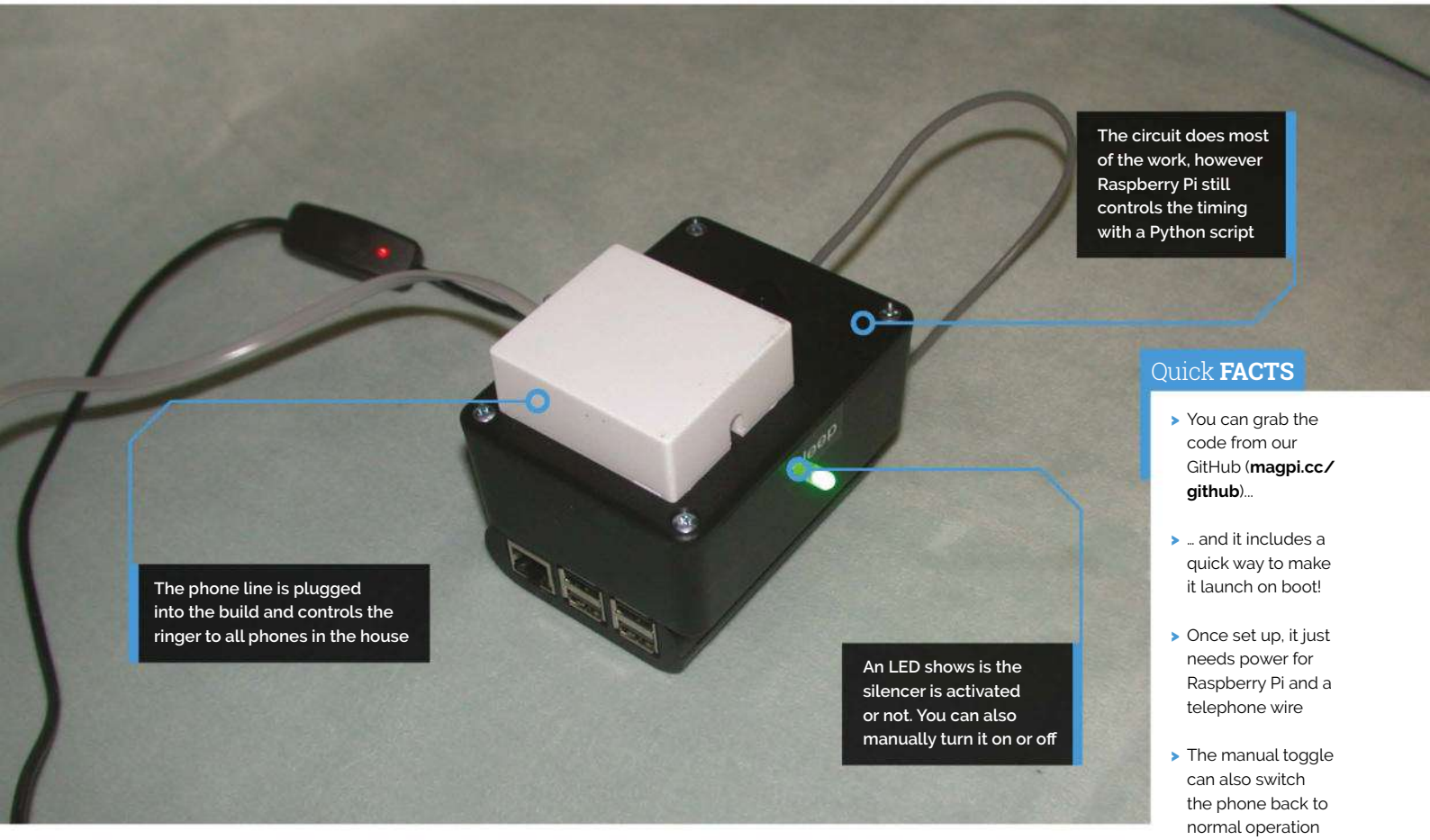
We feel like everyone needs some kind of maker room if they can manage it. Barry though is a professional.

"I have my own electronics lab in my house," Barry mentions. "Including lots of spare parts, and very sophisticated test equipment, having worked as an independent consultant engineer for many years. That makes building these tiny projects a breeze for me."

The tiny project involves a little more hardware than software, as it is connected directly into the phone. You can follow along to **Figure 1** for the explanation by Barry on how it works.

"The telephone line attaches to the Ring Detector (components C1, D1, D2, D3, R1, and the input to IC1 the optocoupler). Zener diodes D1 and D2, combined with capacitor C1, allow only high-voltage AC signals to reach the input of the optocoupler. Normal voice and dialling tones don't affect the ring detector at all. The Ring Signal satisfies these high-voltage AC requirements as it is an 80V RMS (113V zero to peak) AC signal superimposed on the 47V DC idle phone line voltage.

"When the phone rings, the input of the optocoupler gets activated. The output of the optocoupler then turns on driving R2 to nearly 5V DC into the gate of the MOSFET Q1, which momentarily loads down the telephone line with 680ohm resistor R3 signalling the phone company to shut off the ring signal. This happens


The circuit does most of the work, however Raspberry Pi still controls the timing with a Python script
The phone line is plugged into the build and controls the ringer to all phones in the house
An LED shows is the silencer is activated or not. You can also manually turn it on or off

Quick FACTS

- You can grab the code from our GitHub (**magpi.cc/github**)...
- ... and it includes a quick way to make it launch on boot!
- Once set up, it just needs power for Raspberry Pi and a telephone wire
- The manual toggle can also switch the phone back to normal operation
- While it uses Raspberry Pi 3B+, it will work on just about any other Raspberry Pi

so fast that you don't even hear the phone ring. This describes the operation of the circuit when it is in the 'Sleep' mode."

> The tiny project involves a little more hardware than software, as it is connected directly into the phone

The Raspberry Pi controls switching sleep mode on or off via powering GPIO pins with a Python program that gets the time from NTP (Network Time Protocol). There's also a manual toggle in case you're going to bed early.

Like a baby

"I get a much better night's sleep just knowing that I will not have my slumber interrupted by another annoying telemarketing call at six in the morning," Barry tells us.

When we asked about the success of the project, Barry seems not to think there's much mass appeal for a project like this, as everyone just uses 'do not disturb' on their smartphones. While perhaps true, we still think there are plenty of folks who would love to have some manual control over their old landline.

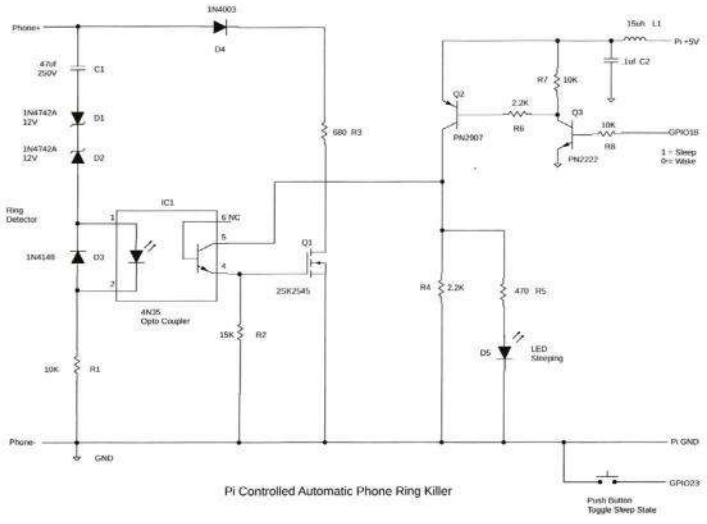


Figure 1: The schematic diagram for the Ring Killer gives an idea of how it all works

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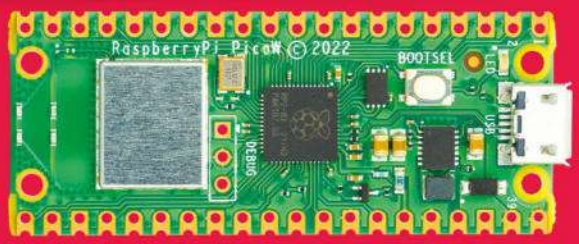

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Yodeck

Raspberry Pi's "amazing balance between power and cost" supports a worldwide digital signage success story. By **Rosie Hattersley**

Digital signage has become a multi-billion-dollar industry. Yodeck was quick to predict the potential: the firm needed hardware to support its reliable, cost-effective, and easily managed service, with no compromise on performance. Raspberry Pi 4 proved a perfect match.

Digital signage company Yodeck was founded in 2014, having emerged from a previous firm that provided digital displays and signage based around PCs. The Athens-based business has a staff of 60 with offices in Cyprus and in the US, and is active in 135 countries. It is a successful participant in a worldwide digital signage market that, from a standing start a decade ago, is set to rise to $45 billion by 2030, according to analysts Grand View Research. The company was set up by CEO Vangelis Mihalopoulos, who has a background as a software engineer but was also drawn to business. Mihalopoulos and his co-founder Dimitris Tsingos recognised the emerging digital signage market and set about launching a new enterprise. Their first product was a PC-based proposition, but their chosen hardware setup didn't take off and the success they enjoyed in their native Greek market was built around too specialised a product.

THE CHALLENGE

Mihalopoulos and his colleagues quickly realised that cost and scalability were constraining issues in their nascent digital signage portfolio. Their existing product's appeal and scalability were

limited, while the production and maintenance costs of a PC-based digital signage offering meant it was also very expensive. In the early days of digital signage, businesses found it convenient to save images and video clips to a USB thumb drive, connect it to a laptop or desktop computer, and play their marketing and sales information that way. However, this was both insecure and unreliable: an unguarded USB device could easily be swapped for one playing unwelcome content, and the drive might be hacked, fail, or simply fill up. Meanwhile, the content itself would need to be updated manually. A better approach would be to push content automatically to client devices, ensuring consistent messaging across different displays and different sites or franchise locations. Mihalopoulos was quick to grasp this issue, and set about creating a solution that would deliver just such a multi-screen service.

> The ability to provide remote support and troubleshooting for Yodeck's digital signage displays was essential

THE SOLUTION

Yodeck began with a screen-first approach, working with San Francisco-based startup Flipnode to create a simple interface for its cloud-based business. Having realised that Raspberry Pi would work well as the hardware basis of their solution and would help Yodeck deliver "an affordable, yet powerful, digital signage platform", they developed a Python-based application to use with Raspberry Pi that would handle content playback, scheduling, device management, and other aspects of the service. "We actually built the business after we saw Raspberry Pi," says Mihalopoulos. "We were inspired by the power and the flexibility of Raspberry Pi, and we decided that it was a perfect match for what we were considering. We realised it would be a great opportunity for the global market." The plan was to provide a managed digital signage service to customers of any size, "from multinationals to the small shop around the corner, and to do so in a reliable but cost-effective way, without making big sacrifices in performance."

WHY RASPBERRY PI?

Yodeck chose Raspberry Pi because it was affordable, powerful and reliable, it provided high quality in a small form factor, and it was available to buy in so many territories globally, matching Yodeck's international ambitions. The ability to provide remote support and troubleshooting for Yodeck's digital signage displays was essential, and access to the underlying code for Raspberry Pi's Linux operating system made this readily attainable. It's vital that both customers and

Yodeck's support team are able to remotely monitor each device's screen status and the status of the Raspberry Pi hardware itself. "From the very beginning, we wanted to offer a service that offers ease of use and affordability," Mihalopoulos told business tech site **Startup.info**. Yodeck currently has a five-strong team dedicated to developing software exclusively for use on Raspberry Pi.

> "From the very beginning, we wanted to offer a service that offers ease of use and affordability"

Mihalopoulos says a key factor in Yodeck's global expansion was selling a product that's based on a known and respected single-board computer that can be bought in customers' own countries. For example, in South Africa – an overseas market for Yodeck, whose offices are in Europe and the US – they have 2000 business customers.

THE RESULTS

Customers use Yodeck's content management system to create playlists and screen layouts using the photos, graphics, and video clips they upload. Playback can be scheduled, and layouts and messaging updated, all from an online dashboard; where no internet connection is available, it can also be played locally from an SD card. It's a model that has proved resilient to a global pandemic, economic downturns, and changing digital consumption trends. The company offers a range of hardware options. Many long-term Yodeck customers begin with a single, free-to-use Yodeck installation and then add more screens once they have trialled the setup and as their digital signage needs increase or the advantages become more apparent. Models include the Raspberry Pi 4 Model B version with 16GB SD card and an Argon40 Neo case; the hardware is provided free to anyone signing up for a year-long Yodeck subscription. However, Yodeck also works on any model of Raspberry Pi, including NEC displays fitted with Raspberry Pi Compute Modules 3 and 4. Approved resellers purchase Raspberry Pi hardware locally and assemble Yodeck Players themselves, "adding to the flexibility of not having to stock specialised hardware," Mihalopoulos explains.

ARGON POD

Designed for
Raspberry Pi Zero 2 W

UNITE AND BUILD

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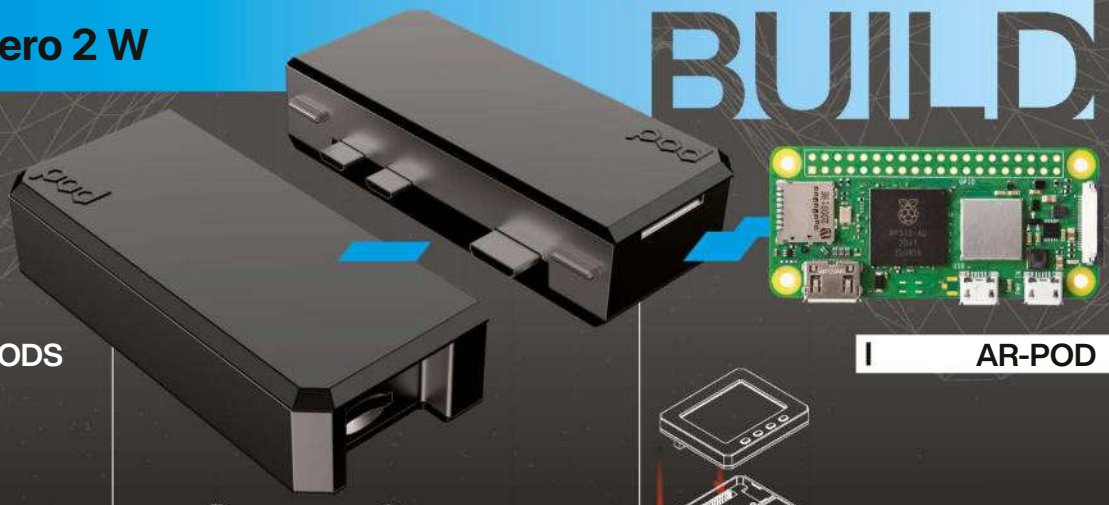
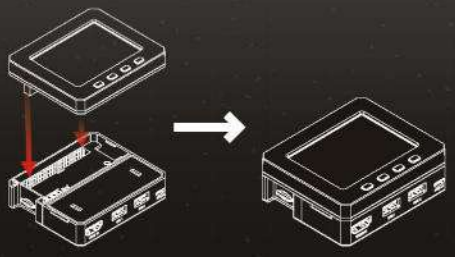
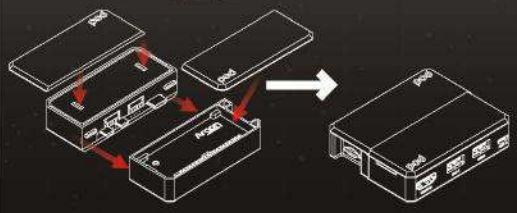


RISE OF THE PODS

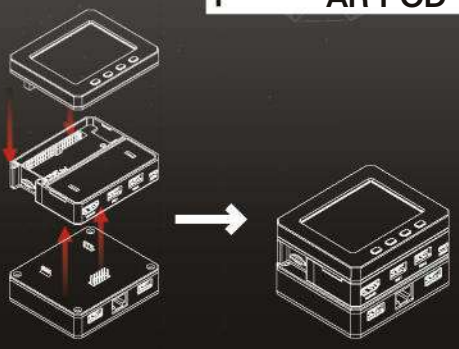
AR-POD



DISPLAY via GPIO



HDMI-USB HUB



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BUILD A UNIVERSAL MEDIA PLAYER

Turn your Raspberry Pi into a dedicated home entertainment system

By **Phil King**

As well as being a versatile general-purpose computer, Raspberry Pi can act as a low-cost, customisable media player system for all your home entertainment needs. Watch movies, TV shows, and videos, listen to music, and more. You can even add a Raspberry Pi TV HAT for live TV viewing and PVR functionality.

We'll explore the software and operating system options for your Raspberry Pi media player, along with some of the best cases and remote controls available. There's also a step-by-step guide to installing and using LibreELEC.

CASES & REMOTE CONTROLS

Protect your Raspberry Pi media player with a case and control it with a remote

ARGON ONE M.2

£40 / $42

It's one of the most popular media player cases for good reason. As well as providing a cool-looking enclosure for your Raspberry Pi 4, the Argon One M.2 has room for a slimline M.2 SATA SSD (available separately) in the bottom section. With UASP support, this enables super-fast data transfer speeds. The only slight downside is that a U-shaped USB adapter to bridge the upper and lower case sections uses up one of Raspberry Pi's USB 3.0 ports.

Still, the sleek all-in-one case re-routes and converts the micro-HDMI ports to full-size ones on its rear. It also has a built-in IR receiver to use with the optional Argon One remote.

As well as passive cooling, the case has a built-in fan with controllable speed via a script, enabling overclocking without throttling for maximum performance.

Check out the full Argon One M.2 review in *The MagPi* magazine issue #100 (**magpi.cc/100**).

MAGPI.CC/ARGONM2

DESKPI PRO V2

£56 / $58

If you prefer your media player to be housed in rectangular 'TV box' style to match the rest of your AV setup, this could well be the case for you.

Featuring an NUC-style aluminium alloy body for improved protection, with acrylic side panels to help the Wi-Fi signal, the DeskPi Pro V2 is a versatile enclosure. Internal adapter boards re-route Raspberry Pi's ports to the case exterior, including two full-size HDMI sockets and a GPIO header on the rear. Even better, they enable you to mount either a 2.5″ or M.2 SATA SSD for high-speed storage.

Safe shutdown and reset functions are also available, while a built-in ICE cooler with PWM controllable fan prevents overheating. If you don't need the SSD, a Lite version of the case is also available (**magpi.cc/deskpilite**).

MAGPI.CC/DESKPIPRO

52PI ALUMINIUM NAS CASE

£36 / $38

52Pi's Aluminium NAS Case comes in two versions: one is equipped with a standard cooling fan and heatsink, while the other features a desktop PC-style ICE tower cooler system with a central copper heat-pipe and seven-blade LED fan.

Both versions accommodate an M.2 SATA SSD (but not NVME format) in the bottom section for ultra-fast storage. All the ports are re-routed to the exterior for easy access, along with a TF card slot.

MAGPI.CC/52PINASCASE

KODI EDITION FLIRC CASE

£13 / $14

If you don't need the case to incorporate external storage, there are countless standard options available. This one comprises an aluminium heatsink body for passive cooling and features a cool-looking Kodi design lid.

MAGPI.CC/KODIFLIRC

TV HAT

If you add a Raspberry Pi TV HAT to your media player setup, you can turn it into a fully functional PVR to watch and record digital TV programs (DVB-T2 format, Freeview in the UK), complete with an electronic programme guide (EPG). By installing the Tvheadend tool (also available in LibreELEC's PVR client add-ons), you can even stream live and recorded TV to other devices on your network via a web server. See *The MagPi* issue 75 (**magpi.cc/75**) for a setup guide.

OSMC REMOTE

£13 / $14

The best thing about this remote is that it comes with a receiver USB dongle. Just plug the latter into Raspberry Pi and you're all set up.

While it's designed specifically for the OSMC OS, the remote should still work out of the box with other systems – we tried it on LibreELEC and it worked really well. There aren't too many buttons, but the functions are generic enough for most media player use cases.

Another bonus is that it uses RF (radio frequency) rather than infrared, so you don't need to point it at the receiver for it to work – if only all TV remotes were like this!

MAGPI.CC/OSMCRF

FLIRC USB V2

£19 / $20

This clever USB dongle enables you to use any standard IR remote with your Raspberry Pi media player. A simple GUI application (available for Linux, Windows, and macOS) lets you easily pair media player functions with buttons on the remote you want to use. Once it's set up, you can just plug it into Raspberry Pi and use it.

You can even map remote buttons to keyboard keys and macros to run several commands. So it's ultra-versatile and hackable using a command-line application and developer SDK. FLIRC has also launched a Skip 1s universal remote that works well with it and other media devices.

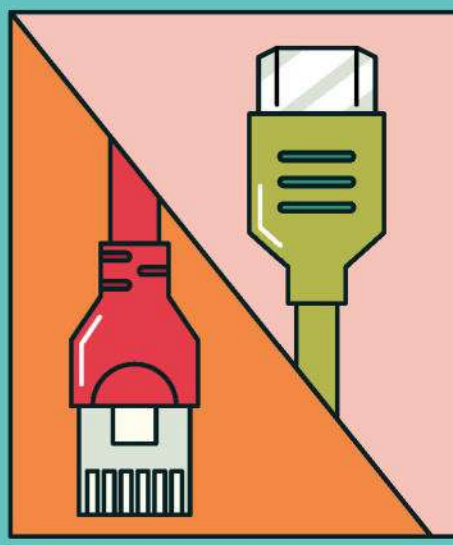
MAGPI.CC/FLIRCUSB

KORE OFFICIAL REMOTE FOR KODI

FREE

You don't even need a physical remote to control Kodi. Available for Android and iOS, this free app gives you convenient control of your media player from your phone. When launched, it searches the local network for media centres; just click on a detected one to connect (entering your username and password) and you're ready to start controlling it. It even syncs your media library to the app interface for easy browsing.

MAGPI.CC/KODIREMOTE



MEDIA PLAYER SOFTWARE

You have a choice of several operating systems for your media player

LIBREELEC

Billed as 'just enough OS for Kodi', LibreELEC is a custom lightweight Linux operating system that can run on Raspberry Pi 2, 3, 4, and 400. The OS image is about half the size of OSMC. It's available to install to a microSD card in Raspberry Pi Imager, although you may want to check out the official LibreELEC downloads page for the very latest version.

Upon first boot, a helpful setup wizard enables you to connect to your Wi-Fi network and enable SSH remote access and Samba sharing. You're then placed in the standard Kodi 'Estuary' user interface – which you can change to a different skin if you prefer. Alongside the usual Kodi add-ons, there are dedicated LibreELEC ones including various decoders, tools, PVR clients, and retro game emulators. There's also a handy LibreELEC settings menu for managing updates, connections, and Bluetooth devices.

Note that LibreELEC is a minimalist OS, so if you want to run other applications on your Raspberry Pi you'd be better off installing Kodi on top of Raspberry Pi OS.

LIBREELEC.TV

OSMC

OSMC (Open Source Media Center) is a lightweight version of Linux Debian for running Kodi. You'll find it in Raspberry Pi Imager, with a choice of versions available for different models; an older version will run on Raspberry Pi 1 and Zero boards. In general, OSMC tends to implement Kodi updates a little later than LibreELEC.

Upon booting up, you're presented with some setup menus (less user-friendly than LibreELEC's wizard) for choosing language, time zone, hostname. You can also enable SSH, which is more useful here as OSMC is a Debian OS, and choose from two user interface skins: OSMC or the default Kodi Estuary UI. For further personalisation, a 'My OSMC' option lets you tweak various settings and configure a remote.

OSMC.TV

XBIAN

As the name suggests, this is a Debian-based lightweight OS for running Kodi. XBian will work on Raspberry Pi 2, 3, 4, and 400 models. Not available in Raspberry Pi Imager's menus, it must be downloaded and installed manually, but there are weekly rolling releases to keep the OS bang up to date – you can install updates from within XBian.

In general, XBian offers a similar Kodi media player experience to LibreELEC and OSMC, with a choice of skins and settings. Features include a VNC server and a bunch of extra packages and tools.

XBIAN.ORG

PLEX

Unlike the other options here, Plex is not based on Kodi. Instead, it acts as a media server for streaming content to other devices rather than playing it locally. While this is possible in Kodi by setting up a UPnP server, Plex makes it easier and supports a wide range of formats/codecs with built-in transcoding.

Note that Plex is not an OS, but an application that you can install manually in Raspberry Pi OS, which takes a few steps. Once launched, a setup wizard guides you through adding your media libraries and choosing settings, including the ability to access the Plex server from outside your local network – via the Plex website. There's also the option to pay for a Plex Pass for extra online content if you want.

PLEX.TV

RASPBERRY PI OS (KODI)

If you want to use your Raspberry Pi to run other applications alongside your media player, your best option is to install Kodi manually in Raspberry Pi OS. Just make sure the system is up to date and use the command `sudo apt install kodi`. If you want the very latest Kodi version, however, you may need to build it from source.

Since RetroPie is based on Raspberry Pi OS, you can also install Kodi within that, using the package manager (it's in Optional Packages).

MAGPI.CC/RPIOSKODI

SET UP A LIBREELEC MEDIA PLAYER

Install the LibreELEC OS on Raspberry Pi and start using it

You'll Need

- Raspberry Pi 4 (or 2, 3, or 400)
- 4GB+ microSD card
- Raspberry Pi Imager **magpi.cc/imager**
- USB external drive
- Remote (optional)

Top Tip

Samba sharing

For SMB/Samba sharing to work, you may need to add a username and password in the settings for it, and also add/enable that user on the NAS device to access the shared folder.

Based around Kodi, the lightweight LibreELEC OS works out of the box on Raspberry Pi. Let's take a look at how to install it, then set it up to play media stored locally on a connected USB drive, and also on NAS over the network.

01 Install LibreELEC

The easiest way to write LibreELEC to a microSD card is to use the Raspberry Pi Imager tool (**magpi.cc/imager**). Select 'Choose OS', then 'Media player OS' > LibreELEC, and select the version of LibreELEC for your Raspberry Pi model: RPi4 or RPi2/3. Then write it to the attached microSD card as usual.

02 Launch LibreELEC

Insert the microSD card into Raspberry Pi. Connect the latter to an HDMI TV/monitor, keyboard, and mouse. Then turn on the power. You'll see the LibreELEC logo, then, after a little while, the Kodi logo. Finally, the LibreELEC user interface will appear and you're greeted by a helpful setup wizard.

This enables you to choose the language, hostname ('LibreELEC' by default), then connect to your wireless router by choosing its SSID and entering its password. Note that unlike Raspberry Pi OS, you can't preload the Wi-Fi details in Imager's advanced options, as they aren't available for LibreELEC.

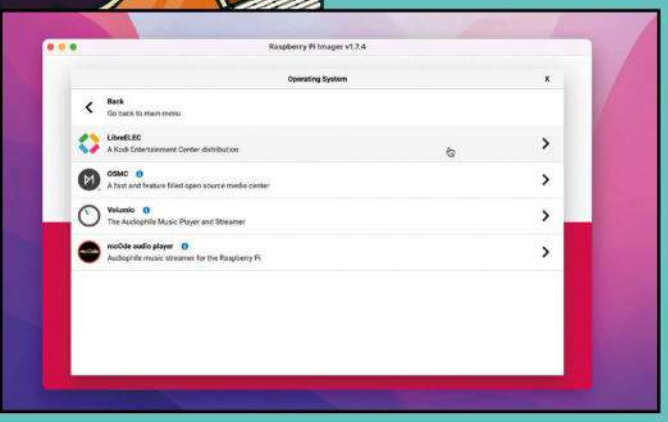
Next, you have the option of enabling SSH for remote access via the terminal – do so and you'll be asked to set a new password for it for security reasons (the default it 'libreelec' with the username 'root'). Finally, click 'Next' to exit the wizard.

03 Navigating the interface

You'll now be able to navigate the LibreELEC interface, which is very user-friendly. Just move up and down the menu items in the left sidebar and select one of the related items shown on the right.

If you have a remote control such as the OSMC Remote, which works out of the box with its USB dongle inserted, you can use it to navigate instead of the arrow keys etc. An on-screen keyboard enables you to type text when needed.

As well as local drives, you can connect to network-attached storage to access its content



▲ You can use the Raspberry Pi Imager tool to write LibreELEC to a microSD card

04 Accessing an external drive

LibreELEC should detect a USB-connected external storage device automatically. To browse the content on it, select the relevant media

> "You can also connect to network-attached storage"

category in the left panel (e.g. Movies or Music), then 'Files' and you should see the name of the drive. Click on it to browse its contents. You can click on a media file to play it.

To add a file to the LibreELEC library, right-click it (or the folder it's in) and select 'Scan item to library'. LibreELEC will then scrape online information for it, including cover art if available. Scanned items will then appear in the right-hand panel in the user interface for the relevant category and can be selected directly. You can right-click one to view info and update it.

05 Accessing network storage

You can also connect to network-attached storage. For a media category, select 'Add videos (or music)', then Browse, select the sharing protocol (e.g. SMB), enter the IP address of the NAS, then the shared folder name (e.g. 'Movies'), then OK.

You should then be able to browse the NAS's contents as with a local drive, and add them to your LibreELEC library.

TV shows / Pluto TV
Sort by: Default · 34 / 165
9:09 AM
WEIRD OR WHAT? WITH WILLIAM SHATNER
...With William Shatner. Lightning Strikes, Human Hibernation, Chinese Anchors: A man survives six lightning strikes, while a toddler is frozen solid and thawed unharmed.
212| Crime Investigation : Crime Investigation Australia - The Greenoug... 1:04:00
211| The New Detectives : The New Detectives - Partners In Crime 1:01:00
300| Pluto TV Paranormal : A Haunting - Hungry Ghosts 1:01:00
213| Crime Scene Solvers : Crime Scene Solvers - Murderous Lovers - An... 1:06:00
Weird Or What? With William Shatner - Lightning Strikes, Humar 49:00
302| Most Haunted : Most Haunted - The National Emergency Services G... 54:00
301| Pluto TV Conspiracy : The Conspiracy Show With Richard Syrett - Rem... 27:00
303| Haunt TV : Paranormal Survivor - When Spirits Take Over 55:00
307| Ghost Hunters : Ghost Hunters - Orphans of Gettysburg 51:00
305| Unsolved Mysteries : Unsolved Mysteries - Episode: 8 54:00
308| Ghost Dimension : Ghost Dimension - Jack The Ripper 52:00
306| Sensing Murder : Sensing Murder - Seeking Siegfried 1:15:00
Options

▲ One of many available video add-ons, Pluto TV offers a selection of free shows to stream

06 LibreELEC add-ons

Click on the Add-ons option in the left menu and you can choose from a host of add-on apps sorted into categories. For instance, the Pluto TV add-on lets you watch a wide range of TV shows and movies for free. Or you could add a weather app to get the latest forecast for your location.

Getting the YouTube add-on working (and other apps that rely on it) is a bit of a faff, as you now need an API key to use it in LibreELEC. This involves setting up a Google Cloud developer project, adding your Google account as a test user, and then copying the API key, client ID, and client secret to the YouTube add-on's API settings. You then need to sign in to your Google/YouTube account (by entering a code on another device) twice in LibreELEC. But once you're in, it works a treat.

Top Tip

Kodi wiki

If you encounter an issue or aren't sure how to do something, the extensive Kodi wiki should have the answer: **kodi.wiki**

▼ Once your content is added to the LibreELEC library, it'll show up in the right-hand panel

Make a Pico LCD true or false quiz game

An LCD display can display messages from Raspberry Pi Pico. In this project, the display is used as part of a quiz game

MAKER

Stewart Watkiss

Also known as Penguin Tutor. Maker and YouTuber that loves all things Raspberry Pi and Pico. Author of *Learn Electronics with Raspberry Pi*.

penguintutor.com
twitter.com/stewartwatkiss

In this tutorial, we will create an interactive true or false quiz game using a Raspberry Pi Pico and an LCD display. Whilst doing so, you will learn about some of the pitfalls when connecting to devices running at different voltages. You'll discover ways to increase voltage output using a simple buffer, and how to make a bidirectional level shifter. The level shifter is then used to convert between 3.3V for the GPIO ports on a Pico to 5V used by the LCD display. The game is programmed in Python, with a text file for the questions. The game can be installed inside an enclosure for a complete game.

You'll Need

- LCD display with PCF8574T **magpi.cc/ihaospacelcd**
- I2C safe level-converter **magpi.cc/BSS138**
- 3 × 16 mm button switches **magpi.cc/16mmbutton**

01 LCD character display

This project is based around an LCD display. Our display has 16 characters across two lines and is often referenced as a '1602'. These usually contain an HD44780, or equivalent, driver chip that displays the appropriate pixels that make up the characters.

One downside of the display is that the driver chip needs at least six data connections. This uses up GPIO ports, as well as needing lots of wires to the LCD display. A common solution is to have a 'backpack' fitted to the rear of the LCD display using a port expander. The example used here is a PCF8574T 8-bit port expander.

02 Designed for 5 V

The port expanders are available on a PCB backpack pre-soldered onto the back of the LCD PCB. This saves you from having to create your own circuit, but it does come with an issue. These circuits are normally designed for 5V, whereas a Pico uses 3.3V for the GPIO ports.

Connecting a 5V signal to a Pico GPIO port could cause permanent damage to the latter, so this tutorial looks at some of the possible solutions to interfacing between devices designed for different voltages.

03 Move pull-up to 3.3 V

If the 5V device did not have a pull-up resistor, the I2C bus could work with pull-ups to the 3.3V supply instead. This is shown in **Figure 2**. The crossed-out resistors are the pull-ups inside the LCD I2C backpack and the two pull-up resistors on the left are connected to the 3.3V output on a Pico. Unfortunately, this involves de-soldering surface-mount devices, which can be difficult.

04 Unidirectional level shifter

A simple form of level shifter can be used when controlling 5V devices from a 3.3V

microcontroller or computer. This is often used for controlling NeoPixels from a Pico or a Raspberry Pi. In its simplest form, this is a MOSFET with two resistors (as shown in **Figure 3**, overleaf). The gate resistor RG (typically 470Ω) reduces the in-rush current, and RL is a pull-up resistor (typically 2.2kΩ to 10kΩ). With no input, the pull-up resistor sets the output high. When a 3.3V input is provided, the MOSFET turns on pulling the output low. This results in an inverted signal.

The code can be configured to invert the output, or you could add an additional MOSFET to invert it a second time. A two-stage, non-inverting buffer is shown in **Figure 4**.

05 Bidirectional level shifter

The LCD is controlled from your Pico, so you may expect the signal would only need to go in one direction. However, due to the use of I2C protocol, signals need to pass in both directions. We need a bidirectional level shifter. These can be made using individual MOSFETS, but using a premade level shifter from Adafruit or SparkFun is more convenient. An example is the Adafruit bidirectional level shifter, which has four level shifters on a convenient PCB. This is shown in **Figure 5**.

The level shifter has just one MOSFET for each channel. This is in an unusual configuration. The circuit can be thought of as two sides, with the left side being for the low voltage and the right for the higher voltage. The MOSFET joins the two together. The schematic diagram is shown in **Figure 6**.

06 How the level shifter works

If both the low-voltage and high-voltage signals are high, then the MOSFET is off and the signal is high at both sides. If the low-voltage signal (left) drops low, then the MOSFET is in the forward direction and the voltage at the gate will turn the MOSFET on. This will provide a path to ground and so the high-voltage signal (right) will be pulled low. If the high-voltage signal (right) goes low, due to an internal characteristic of the MOSFET a small current is able to flow in the reverse direction. As this happens, the voltage of the source pin dips, causing the MOSFET to turn on. This pulls the voltage down on the low-voltage signal as well.

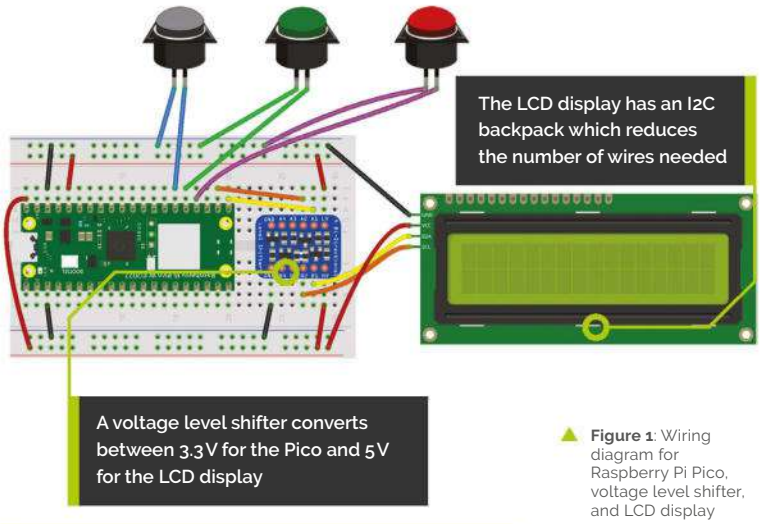

The LCD display has an I2C backpack which reduces the number of wires needed
A voltage level shifter converts between 3.3V for the Pico and 5V for the LCD display

Figure 1: Wiring diagram for Raspberry Pi Pico, voltage level shifter, and LCD display

07 LCD circuit

The level shifter can be inserted onto the breadboard and connected between your Pico and LCD display. Then it's just a case of adding three buttons for Start, True, and False. These are shown in **Figure 1**.

The top power rail is used for 3.3V taken from your Pico's 3.3V output, and the bottom power rail is 5V taken from the VBUS supply from the USB port.

The buttons used are 16mm push-to-make switches, similar to arcade buttons, but smaller. You can use other push-to-make switches if you prefer.

08 Download the LCD library

The libraries that support the LCD display with backpack are available from GitHub (**magpi.cc/rpipicoi2clcd**). Upload the files

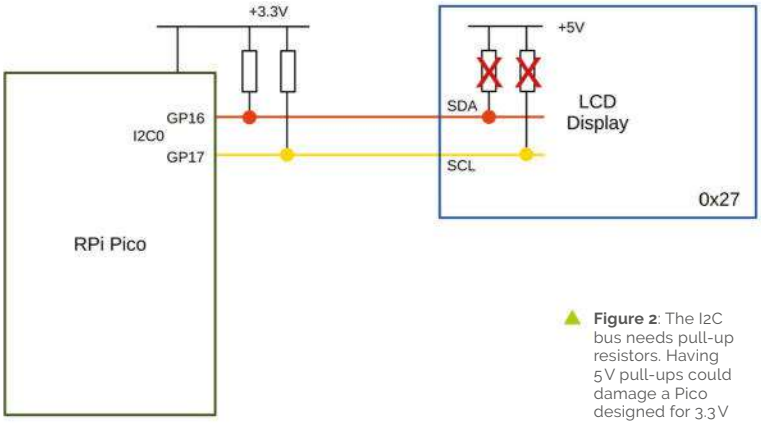


Figure 2: The I2C bus needs pull-up resistors. Having 5V pull-ups could damage a Pico designed for 3.3V

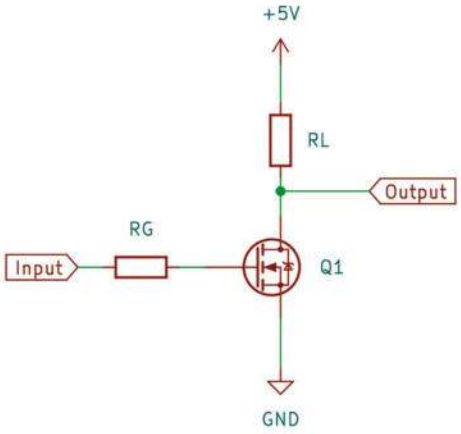


Figure 3: A simple MOSFET level shifter. The output is the opposite of the input but higher voltage

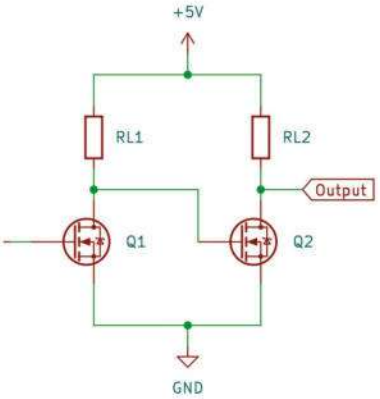


Figure 4: A second MOSFET can be used to create a non-inverting buffer

lcd_api.py and **pico_i2c_lcd.py** to your Pico. You can see a demo using **pico_i2c_lcd_test.py**. This can be useful for checking your wiring is correct, but you will need to change the pins used for SDA (GPIO 16) and SCL (GPIO 17).

09 Coding the game

The game code (**quizgame.py**, overleaf). starts by setting up the three `button` objects, along with `i2c` and `lcd`. It then reads the file **quizfile.txt**, which contains the questions.

Then it enters a loop which ensures that the game can be played over again.

Within the first few lines of the loop, you can see that it first clears the display, puts a string which starts on the top line, moves to the start of the second line, and then puts another string to that line.

10 Handling button presses

The button presses are handled by having a `while` loop which runs until an appropriate button is pressed. In the case of the Start button, it just looks for that one button, but when waiting for a true and false, it needs to check both the `true_button` and `false_button` to see if either is pressed. It keeps track of the score and then displays the score at the end, pausing for five seconds before restarting the game.

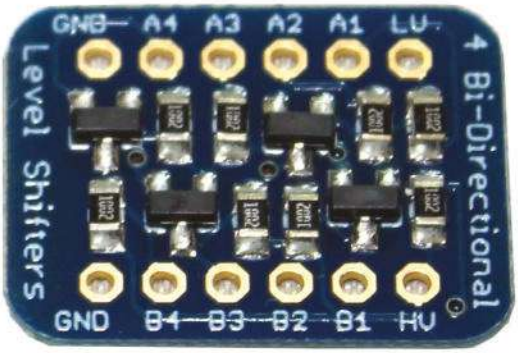


Figure 5: A bidirectional level shifter is available on small PCBs. These can have headers fitted to be used on a breadboard

11 The quiz file

The questions are stored in the file **quizfile.txt**. This has one line per question. Each line should have three entries separated by a semicolon. The first entry is the top line to display, the second is the second line, and the final entry is a letter T or F to indicate whether the correct answer is `True` or `False`.

> "The code to create the game is included"

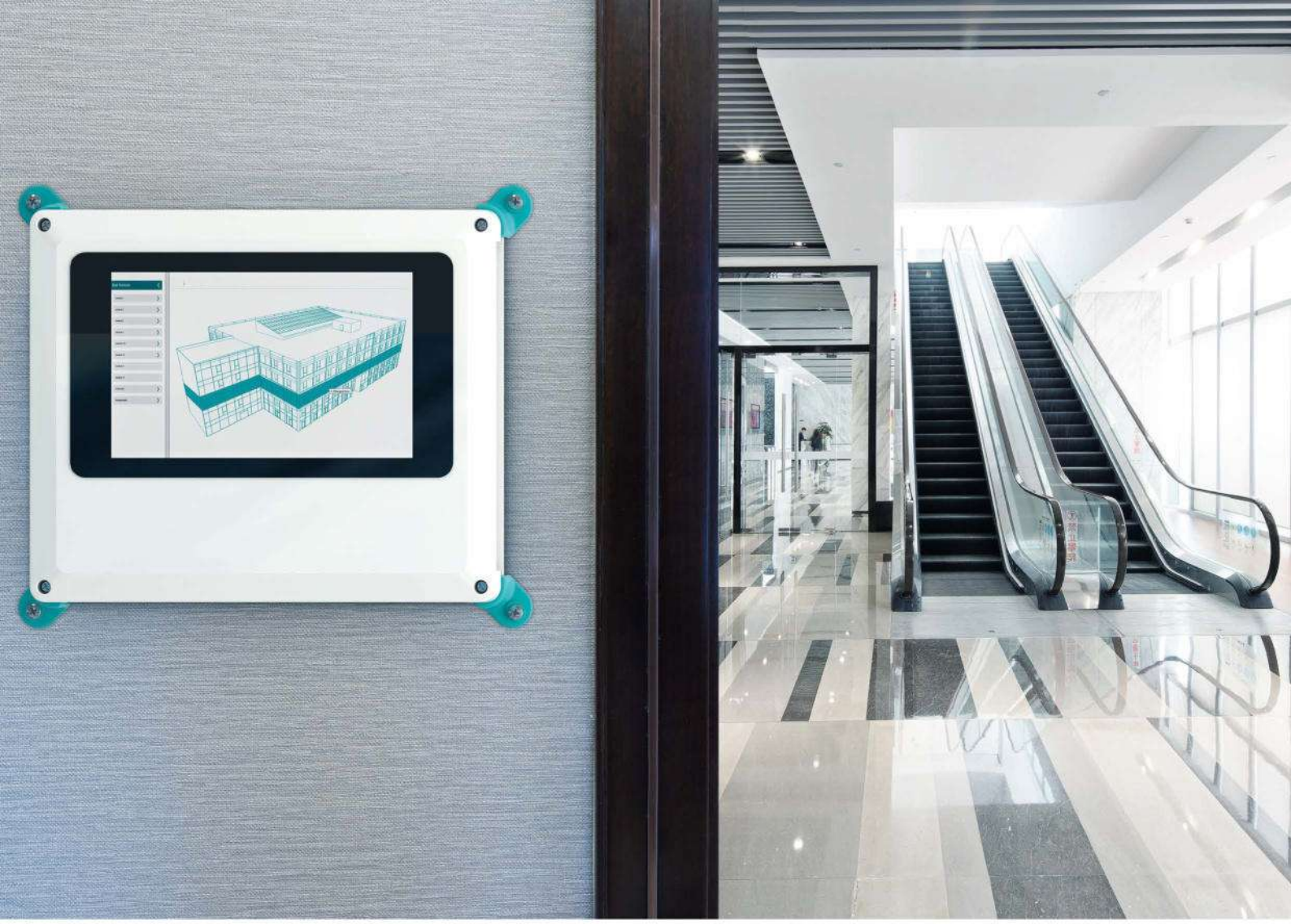
The file is opened using the `with` statement. Using with means that the file will be automatically closed after the program has finished reading in the entries. The `readlines` method is used to read all the entries into a list.

To separate the text to display from the answers, the `split` method is used. You may notice that it also uses the `strip` method to ignore any whitespaces, such as spaces before the newline character.

The quiz file is created separately and must be uploaded to Pico.

12 Improving the game

The game can be placed in an enclosure to make a complete game. You could start with a standard enclosure and cut holes for the display and buttons, or if you have a 3D printer you can



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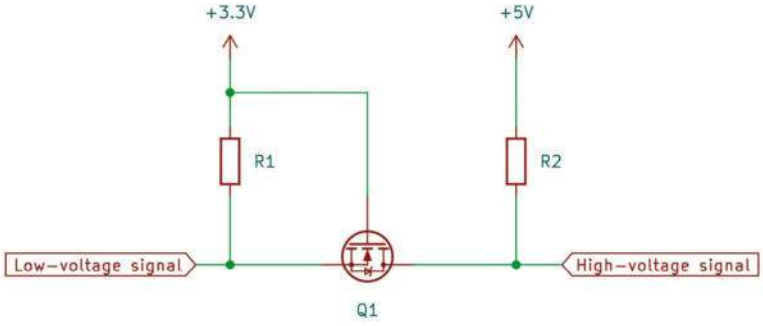

Figure 6: The bidirectional level shifter uses two MOSFETs. This works well for signals with pull-up resistors like I2C

download an example from the Penguin Tutor website (**magpi.cc/trueorfalse**). One improvement would be to add some error checking. Without error checking, if there is an invalid entry in the quiz file, the program may crash.

Another possible improvement would be to provide a way to add multiple quizzes rather than just limiting them to a single quiz.

Figure 7: The game can be placed inside an enclosure. If you don't have a 3D printer, you can use a generic case and cut appropriate holes

quizgame.py

DOWNLOAD THE FULL CODE:
magpi.cc/picolcdquiz

> Language: **MicroPython**

```
001. import utime
002. from machine import Pin, I2C
003. from lcd_api import LcdApi
004. from pico_i2c_lcd import I2cLcd
005.
006. I2C_ADDR     = 0x27
007. I2C_NUM_ROWS = 4
008. I2C_NUM_COLS = 16
009.
010. start_button = Pin(20, Pin.IN, Pin.PULL_UP)
011. true_button = Pin(19, Pin.IN, Pin.PULL_UP)
012. false_button = Pin(18, Pin.IN, Pin.PULL_UP)
013.
014. i2c = I2C(0, sda=machine.Pin(16),
     scl=machine.Pin(17), freq=400000)
015. lcd = I2cLcd(i2c, I2C_ADDR, I2C_NUM_ROWS,
     I2C_NUM_COLS)
016.
017. lcd.hide_cursor()
018.
019. # Read questions into a list
020. with open("quizfile.txt", 'r') as file:
021.     questions = file.readlines()
022.
023. while True:
024.     lcd.clear()
025.     lcd.putstr("True or False")
026.     lcd.move_to(0,1)
027.     lcd.putstr("Press Start ...")
028.
029.     while True:
030.         if (start_button.value() == 0):
031.             break
032.     # Quiz start
033.     score = 0
034.     for question in questions:
035.         lcd.clear()
036.         # strip off any whitespace
037.         # then split the entries into line1, 2 and
     answer
038.         (text, text2, answer) =
     question.strip().split(";", 3)
039.         lcd.putstr(text)
040.         lcd.move_to(0,1)
041.         lcd.putstr(text2)
042.         while True:
043.             if (true_button.value() == 0):
044.                 if (answer == "T"):
045.                     score += 1
046.                 break
047.             if (false_button.value() == 0):
048.                 if (answer == "F"):
049.                     score += 1
050.                 break
051.     lcd.clear()
052.     lcd.putstr("Game over")
053.     lcd.move_to(0,1)
054.     lcd.putstr("Score {} of {}".format(
     score, len(questions)))
055.     utime.sleep(5)
```

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POWERED BY Raspberry Pi

Part 04

Camera Module: The preview window

Before taking a shot, you'll use the preview window to check it. Discover how this window works and what your options are

MAKER
David Plowman

David is an engineer at Raspberry Pi with a special interest in camera software and algorithms, and image processing hardware.

raspberrypi.com

So far, especially with a keyboard and screen plugged directly into your Raspberry Pi, you haven't had to worry too much about the camera preview window. It just works. Nonetheless, we do have some control over it, for example its size, and there are a few tips worth knowing.

There are three different types of preview window: OpenGL, DRM, and Qt. Normally, the most appropriate type is chosen automatically, but there may be times when it's worth knowing about your options.

OpenGL preview window

When you're running Raspberry Pi OS with the desktop environment, and a display is connected directly to your Raspberry Pi with an HDMI cable, then OpenGL is the preview window you will get.

It has the benefit of using the built-in 3D graphics hardware to optimise the rendering of the camera images, thereby leaving your device's CPU (central processing unit) available for other tasks.

The OpenGL preview window does have some minor limitations. On Raspberry Pi 4 it won't be able to display a camera image that is more than 4096 pixels across. On lower-powered devices (such as Raspberry Pi 3), the limit is 2048 pixels. It would be unusual to create camera images wider than this for preview, so this doesn't normally pose a problem.

When you're running in the desktop environment, the OpenGL preview will open automatically.

DRM preview window

When Raspberry Pi OS is not running in the desktop windowing environment (for example, when logging in directly to the console), you will use the DRM preview window. If you are running the desktop environment, you can normally suspend it with **CTRL+ALT+F1** to drop out to the console environment, giving the same result (and use **CTRL+ALT+F7** to switch back).

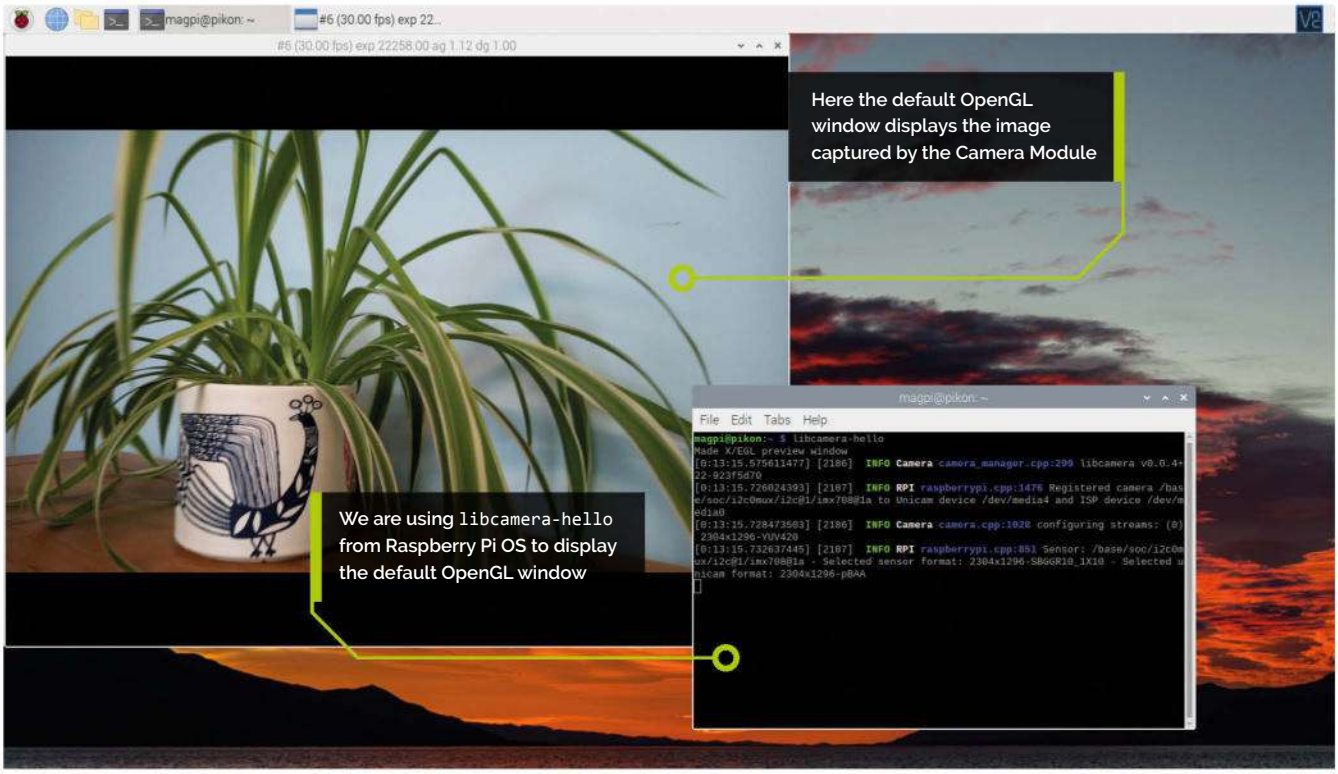
You'll Need

- Raspberry Pi
- Raspberry Pi Camera Module
- Raspberry Pi OS

Top Tip

DRM?

DRM in this context is not related to the more commonly known 'digital rights management', which is used to control access to digital video and music files.


Here the default OpenGL window displays the image captured by the Camera Module
We are using libcamera-hello from Raspberry Pi OS to display the default OpenGL window
magpi@pikon: ~
File Edit Tabs Help

DRM stands for 'Direct Rendering Manager' and is a Linux interface for rendering to graphics devices. This is probably the most efficient way to render camera images to the screen as the task is taken over completely by your Raspberry Pi's display hardware. Unfortunately, X11 (which implements Raspberry Pi OS's desktop environment) assumes sole control of the DRM interface, which is why the DRM preview is only available when X11 is not running, or is suspended.

In this environment, obviously enough, the window has no title bar, nor is there any way to 'grab' it and move it around the screen.

When you are in the console environment, the DRM preview will open automatically.

Qt preview window

The Qt (pronounced 'cute') preview window is, in some respects, similar to the OpenGL preview window in that it is available when running in the desktop environment. It's implemented using the Qt graphical user interface (GUI) toolkit, but the principal difference, from our point of view, is that the rendering is done in software (by the CPU) and not by the dedicated 3D graphics hardware. Because of this, normally the Qt preview window is a bad idea, but you may want to use it if:

> When you're running in the desktop environment, the OpenGL preview will open automatically

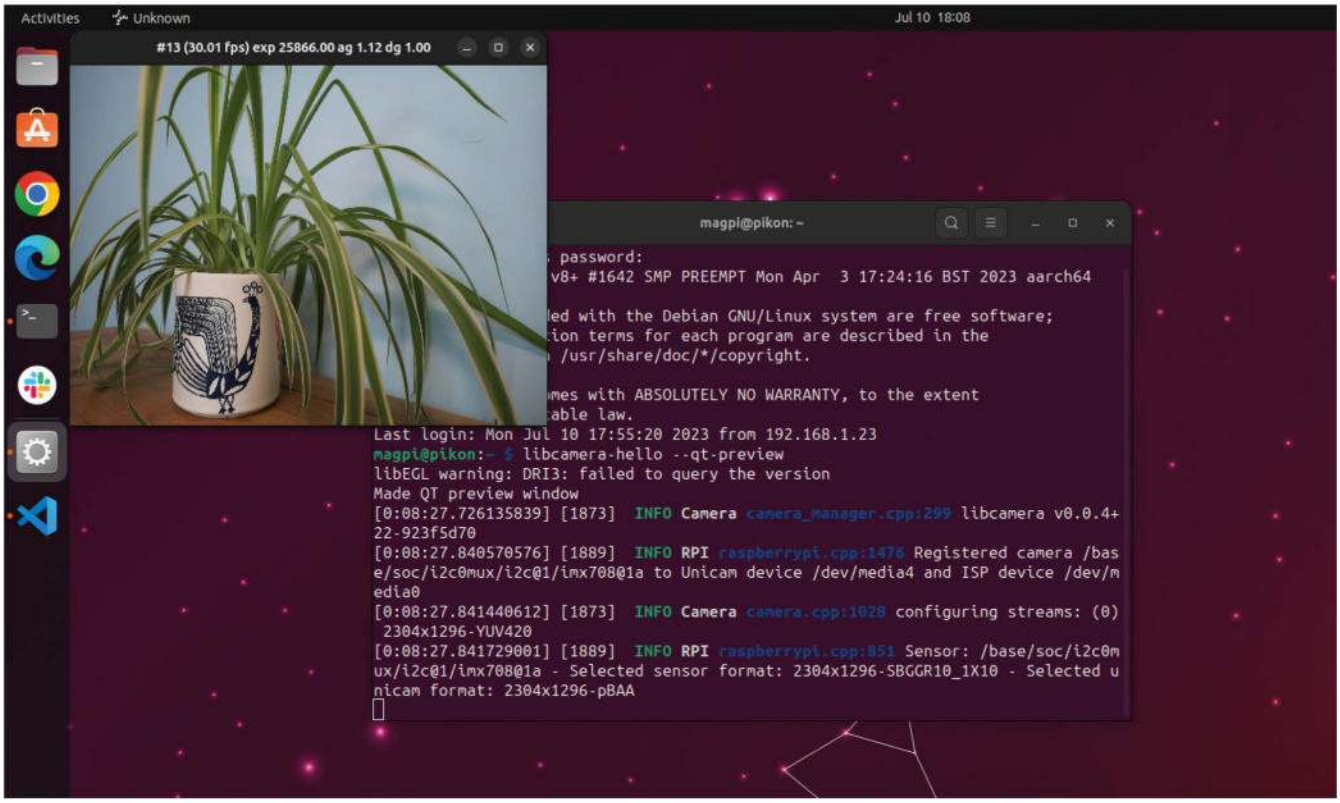
- You're logged in remotely using SSH.
- You're viewing Raspberry Pi's desktop remotely using VNC.

When logged in remotely using SSH, you can forward the preview window to the machine where you are sat, rather than show them on any locally attached monitor (if there is one). You'll need to log in with X forwarding enabled, like this:

```
ssh -X user@your_pi
```

...replacing `user@your_pi` with the correct login for your own device.

Now you need to add `--qt-preview` to the command line of the libcamera application that you wish to use. All the applications behave identically in this respect. So if you only want to see the camera images, use:


Activities
Unknown
Jul 10 18:08
#13 (30.01 fps) exp 25866.00 ag 1.12 dg 1.00
magpi@pikon: ~
password:
v8+ #1642 SMP PREEMPT Mon Apr 3 17:24:16 BST 2023 aarch64
ed with the Debian GNU/Linux system are free software;
ion terms for each program are described in the
/usr/share/doc/*/copyright.
mes with ABSOLUTELY NO WARRANTY, to the extent
able law.
Last login: Mon Jul 10 17:55:20 2023 from 192.168.1.23
magpi@pikon:~ $ libcamera-hello --qt-preview
libEGL warning: DRI3: failed to query the version
Made QT preview window
[0:08:27.726135839] [1873] INFO Camera camera_manager.cpp:299 libcamera v0.0.4+
22-923f5d70
[0:08:27.840570576] [1889] INFO RPI raspberrypi.cpp:1476 Registered camera /bas
e/soc/i2c0mux/i2c@1/imx708@1a to Unicam device /dev/media4 and ISP device /dev/m
edia0
[0:08:27.841440612] [1873] INFO Camera camera.cpp:1028 configuring streams: (0)
2304x1296-YUV420
[0:08:27.841729001] [1889] INFO RPI raspberrypi.cpp:851 Sensor: /base/soc/i2c0m
ux/i2c@1/imx708@1a - Selected sensor format: 2304x1296-SBGGR10_1X10 - Selected u
nicam format: 2304x1296-pBAA

▲ Here we are logged in via SSH (Secure Shell) on another computer and displaying the Qt-preview window from the command line

```
libcamera-hello --qt-preview
```

In the case of VNC, the Qt preview window sometimes runs more smoothly than the OpenGL one, though note that you will be causing a lot of uncompressed video traffic on your network.

Because of the Qt preview window's expense in terms of CPU, it is by default opened with quite a small size.

Preview window options

We have a few command-line options to control the behaviour of the preview window. Let's review those here.

> "The Qt preview window sometimes runs more smoothly than the OpenGL one"

- `--qt-preview` Force the use of the Qt preview window when the OpenGL version would normally have been used.
- `-n` or `--nopreview` No preview window is shown at all (though the camera runs normally). This can be helpful if you simply don't have a display where you can show images, and also in helping very high frame rate video to avoid frame drops.
- `-f` or `--fullscreen` [OpenGL preview only] Causes the OpenGL preview window to run in full-screen mode (normally it runs in a regular medium-sized window).
- `-p` or `--preview` followed by four comma-separated numbers (without any spaces). This sets the size of the preview window. The four numbers are the x offset, y offset, width, and height for the preview window.

Let's see a few examples:

```
libcamera-vid --nopreview -o test.h264
```

Record a video without showing an on-screen preview.

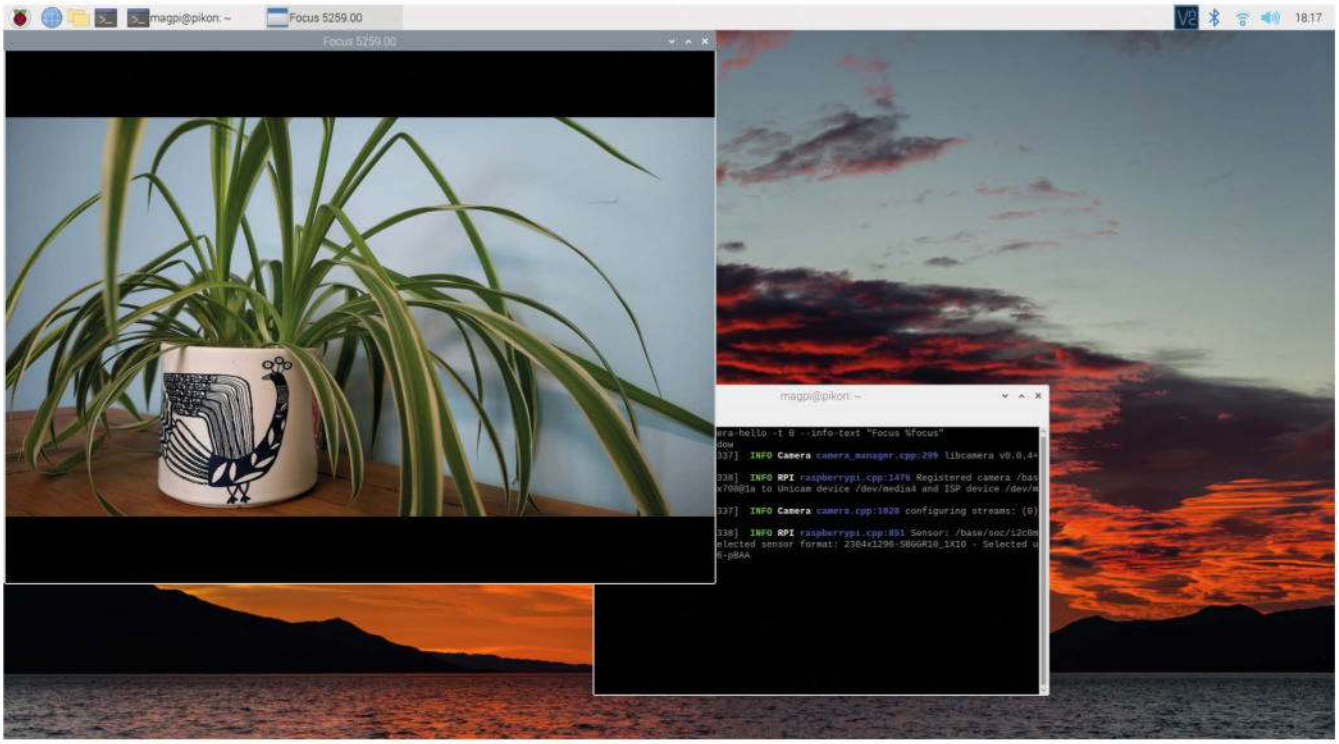
```
libcamera-hello --fullscreen
```

Show the camera preview in full-screen mode.

```
libcamera-hello --preview 100,100,1200,800
```

Show the camera preview in a 1200×800 pixel window, offset 100 pixels in both directions from the top left corner of the screen.

```
libcamera-hello --preview 100,100,1200,800
--qt-preview
```



As above, but force the Qt preview window to be used. Maybe watch the output of the `top` command while this is running, and compare it with the results when you omit `--qt-preview`.

Obtaining live status information

If you're using the OpenGL or Qt preview windows, the camera system can show live status information on the window's title bar. There is already a default selection, showing the current exposure time and gain, and some other things. But you can choose your own values using the `--info-text` parameter.

For example, to display a 'focus measure', you could use:

```
libcamera-hello -t 0 --info-text "Focus %focus"
```

...which will display the string 'Focus' followed by a number indicating how well focused the image is (the higher the number, the more in focus). This is particularly useful for the HQ Camera, allowing the user to adjust the manual focus ring to the best position.

In general, the `--info-text` parameter accepts a free-form text string where certain status fields, beginning with `%`, will be replaced by their live values. The available status fields are:

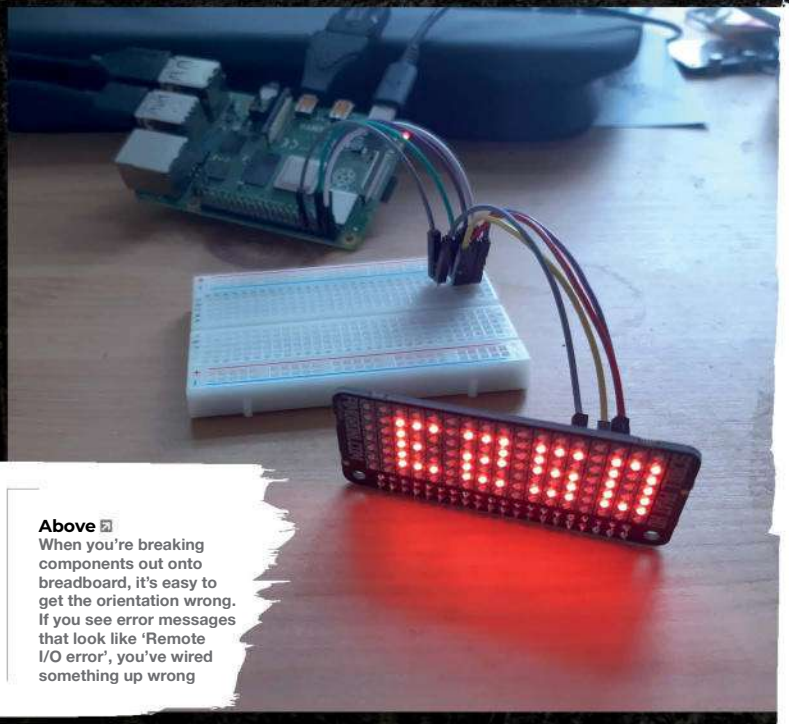
- `%frame` A sequential count of the number of frames delivered.
- `%fps` An instantaneous measure of the current frame rate (in frames per second).
- `%exp` The exposure time of the current frame as reported by the sensor.
- `%ag` The analogue gain of the current frame as reported by the sensor.
- `%dg` The digital gain applied to the current frame.
- `%rg` The gain applied to the red colour channel for white-balancing.
- `%bg` The gain applied to the blue colour channel for white-balancing.
- `%focus` A measure of sharpness (higher = sharper) which can be used for manual focus adjustment.
- `%aelock` Whether the AE (auto exposure) algorithm thinks it has 'settled'.
- `%lp` The current lens position (Camera Module 3 only).
- `%afstate` The current state of the autofocus algorithm. It will report one of 'idle', 'scanning', 'focused', or 'failed' (Camera Module 3 only).

We are using the --info-text option with the focus string to display the focus level in the preview window

IN THE WORKSHOP: Pomodoro timer

By Andrew Gregory

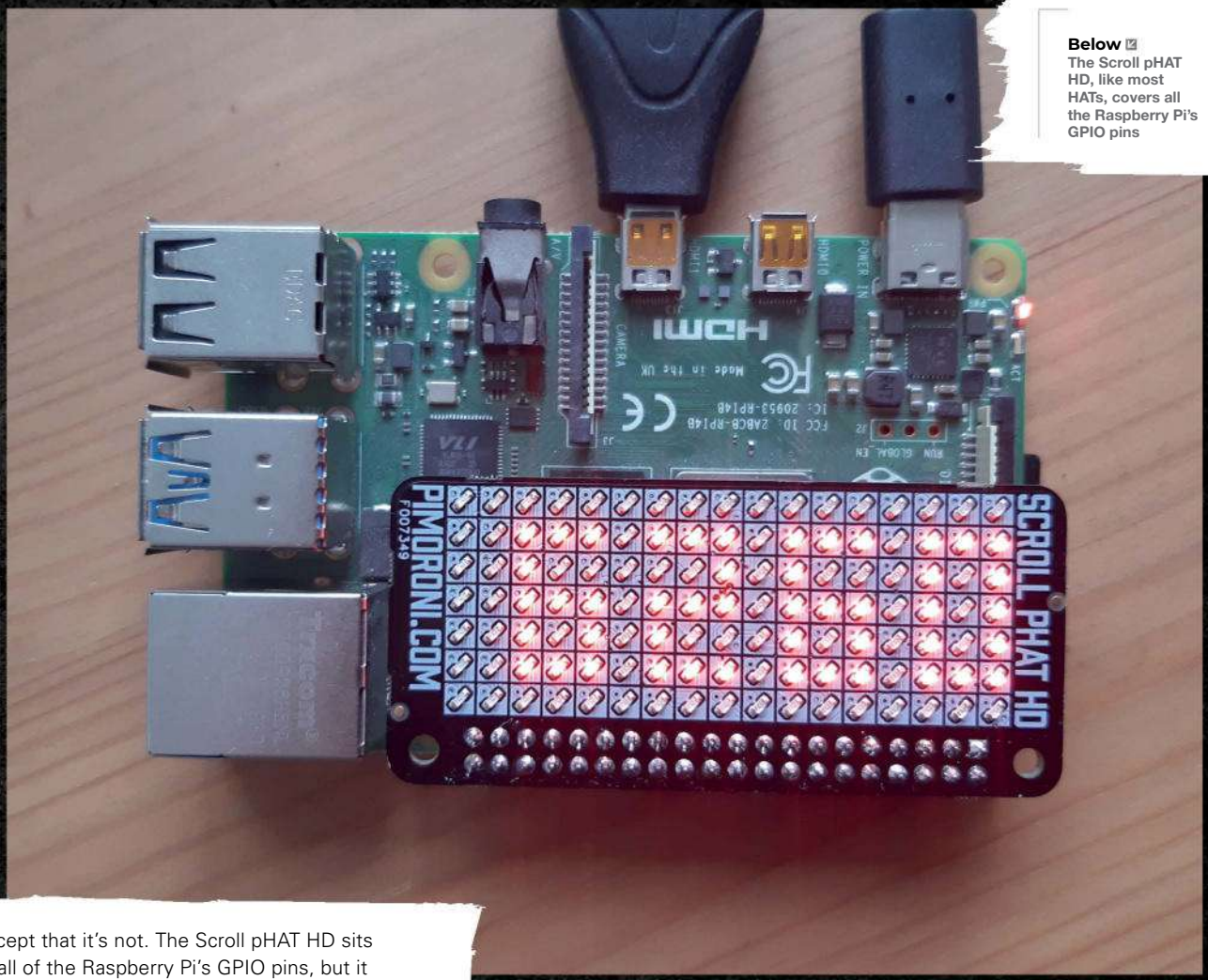
In which we try to do something simple and end up learning about I2C



Above
When you're breaking components out onto breadboard, it's easy to get the orientation wrong. If you see error messages that look like 'Remote I/O error', you've wired something up wrong

This month, I set off with the intention of building a Pomodoro timer controlled by physical movements, rather than buttons or switches. To capture the physical movements, I'd need an IMU, or Inertial Measurement Unit. Pimoroni sells one of these that uses the same motion sensor chip used in smartphones and watches to measure 3-axis acceleration, 3-axis gyroscopic motion, and 3-axis compass heading. I'd also need a screen (Pimoroni is selling off its lovely Scroll pHAT HD displays, featuring 17×7 LEDs, for £6.90 plus shipping), and a real-time clock module to keep the time. I also threw an atmospheric sensor into the basket, because why not?

For now, I'm sticking with Python, as not all the sensors support my first choice, MicroPython. The Scroll pHAT HD fits neatly on the GPIO pins, and with a quick download of Pimoroni's example code, it just works. Now to add the IMU sensor… and there aren't any pins left on the Raspberry Pi. This is impossible.

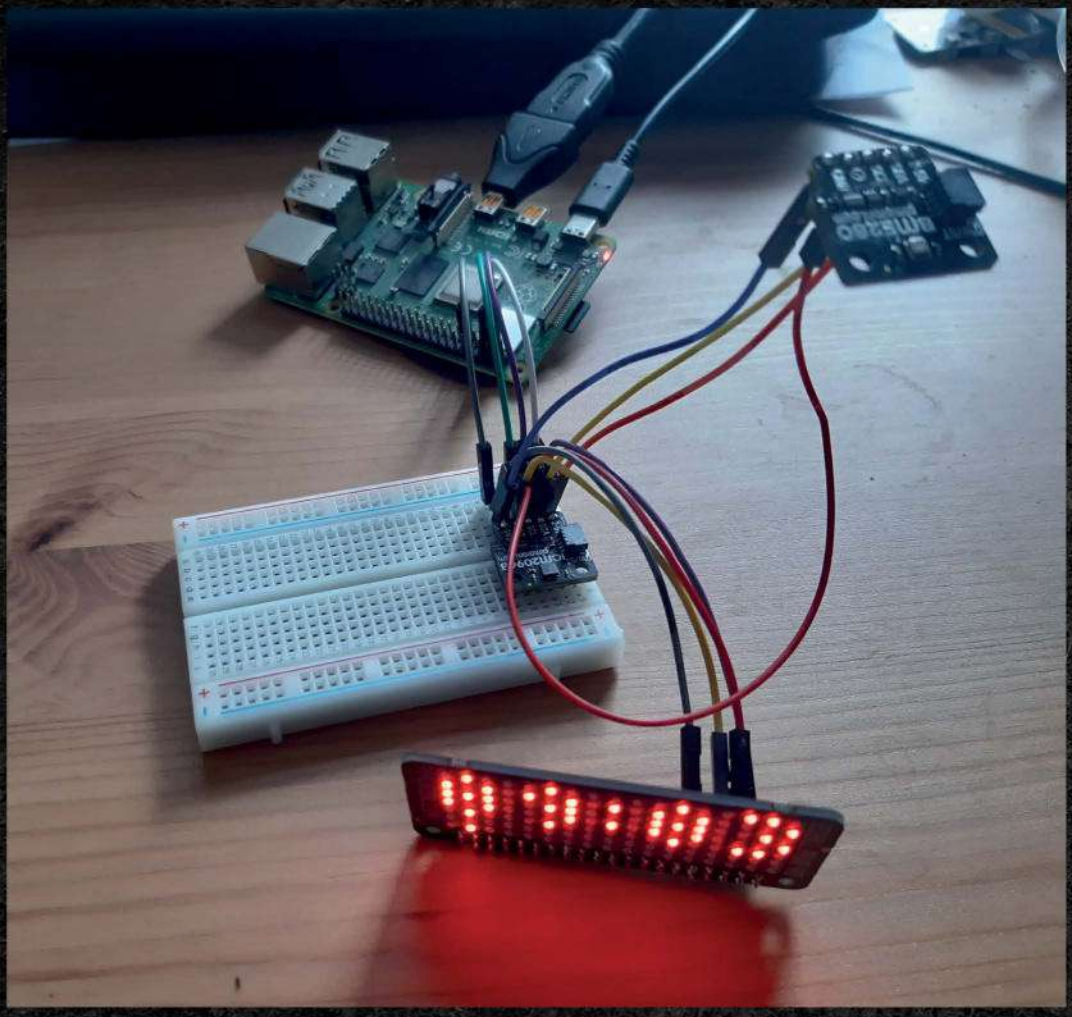


Below
The Scroll pHAT HD, like most HATs, covers all the Raspberry Pi's GPIO pins

Except that it's not. The Scroll pHAT HD sits over all of the Raspberry Pi's GPIO pins, but it can't use them all – surely no device needs three power supplies and eight ground pins, never mind all the rest of the GPIO pins? The answer was found at **pinout.xyz**, by Phil Howard. The device I'm using needs only four pins: 5V power, Ground, and GPIO 3 and 5. That's the good news. The bad news is that the IMU also needs to use those same four pins. It turns out that the atmospheric sensor and real-time clock also use those same four pins. Something is going on here, and that something is I2C.

I2C was invented in the 1980s, as a way for chips to talk to each other. Back then, they didn't →

The bad news is that the IMU also needs to use those same four pins

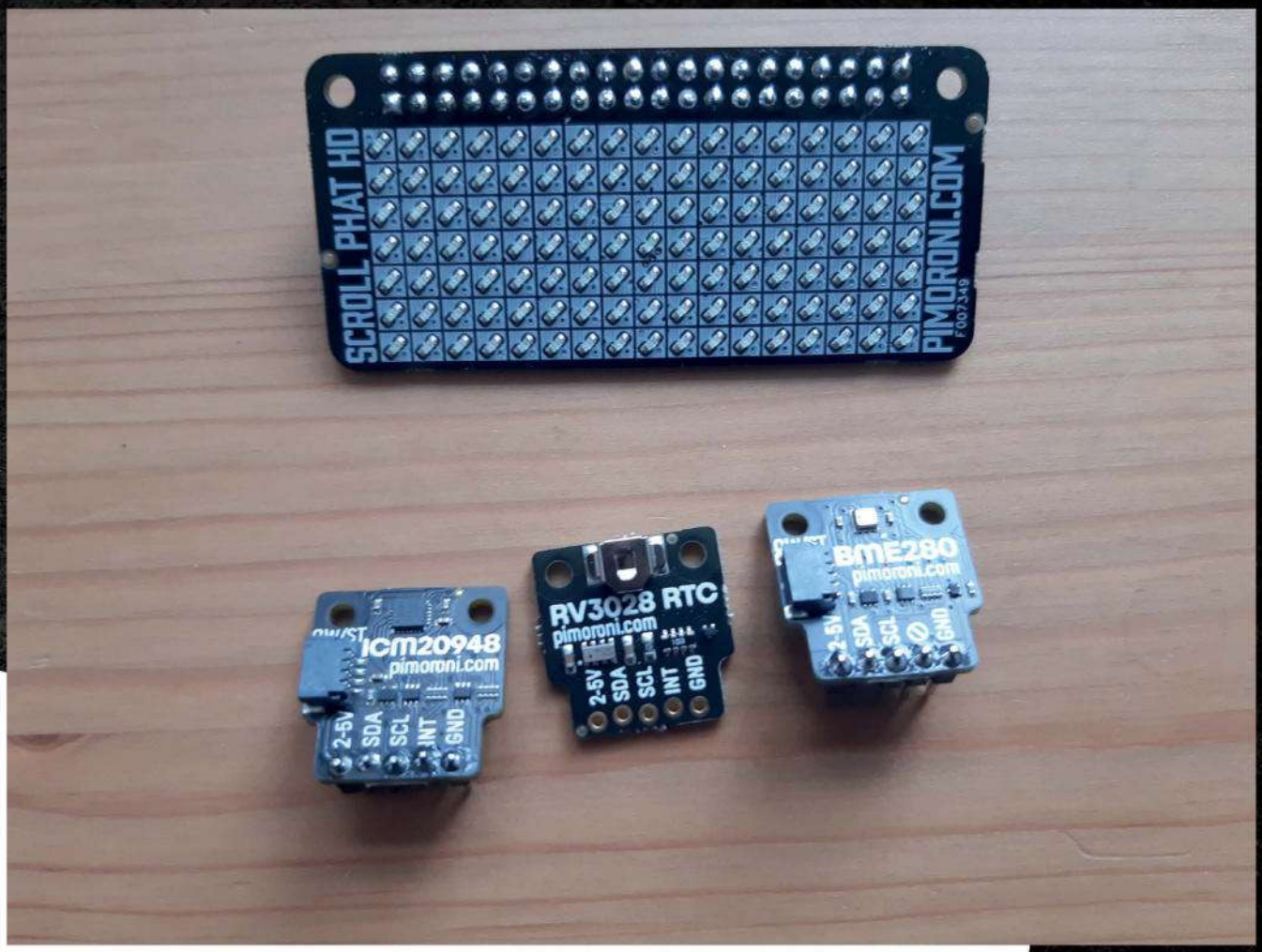


Above
With just three I2C devices connected, our breadboard is looking a little messy

Right
Some devices connect over I2C using the much smaller, neater JST connectors

HackSpace

This tutorial is from HackSpace magazine. Each issue includes a huge variety of maker projects inside and outside of the sphere of Raspberry Pi, and also has amazing tutorials. Find out more at **hsmag.cc**.



Above
The gear we've chosen for this build all uses the same small set of GPIO pins. This is a problem…

have the chip shortage that we're mercifully coming out of right now. Rather, tech companies were starting to put chips in everything, as chips became radically smaller, cheaper, and an all-round better way of controlling devices than using discrete components. Chips are also known as integrated circuits, and it's from here that I2C gets its slightly clunky name: Inter-Integrated Circuit communication.

From this, we can infer correctly that every device that uses I2C has a chip on board. Each chip has a unique address, and I2C supports up to 1008 separate addresses – I'm going to need a bigger breadboard.

If you're using discrete components – say, an LED and a buzzer – you'd need to connect each one to a separate GPIO pin and switch each pin on or off to get current into the component. I2C is more complicated than that. On a Raspberry Pi, the pins that send out data over I2C are pin 3 and pin 5; the I2C device will also need power (pin 1 or 2) and ground (Pin 9). Any I2C device can connect to these same four pins, provided it has a unique device address. The clock module I've been attempting to use has an address of 0x52; the environmental sensor uses 0x76 or 0x77.

To set up the I2C pins on a Raspberry Pi, go into the Raspi-Config tool by entering:

```
sudo raspi-config
```

Now, go to Interface Options, then to I2C. Enable I2C by selecting Yes, and choose to enable I2C every time the Raspberry Pi boots.

Failure is the first step in learning; this has been a frustrating learning curve, but now I know what's possible, we can get cracking.

CITIZEN SCIENCE

WITH RASPBERRY PI

BY AMATEUR INVENTOR
Rob Zwetsloot

WHAT IS CITIZEN SCIENCE?

Citizen science is a way for regular people to aid in scientific discovery by providing extra data en masse. This can be in the forms of surveys or climate data.

Contribute to our understanding of the universe with these fantastic scientific projects

If you've been reading this magazine or the Raspberry Pi blog for a few years, you'll know that Raspberry Pi is used in all manner of scientific endeavours. Medicine, wildlife conservation, geology, and so many other fields have benefited from the existence of Raspberry Pi, purely because it's cheap, reliable, and well-supported by the community.

You don't have to be a tenured professor or salaried research scientist to get in on this either. Raspberry Pi is at the heart of many citizen science projects – ones you can take part in! So pick up your Raspberry Pi and learn a bit more about the world around you.

WEATHER TRACKING

With a HAT and some sensors, you can build your own barometer and track your local climate

TOP TIP

For more ways to practice science with Raspberry Pi, check out the Raspberry Pi Guide for scientists and anyone else: **magpi.cc/scienceguide**

01 Assemble the hardware

The Weather HAT can be installed on any kind of Raspberry Pi with a 40-pin GPIO – so anything other than the original Raspberry Pi 1 A and B. Simply push the HAT down on the pins, orientated so the HAT goes across Raspberry Pi. You can then screw it in via the mounting holes on Raspberry Pi. The wind and rain sensors simply attach to their labelled ports on the HAT with an RJ11 cable – the kind you might use for a phone or modem.

02 Install the software

It's best to use a fresh SD card/install for your weather station. Head to **magpi.cc/imager** and grab the latest version of Imager to install Raspberry Pi OS with desktop. Once all set up, open up the terminal on Raspberry Pi and use:

```
git clone https://github.com/pimoroni/weatherhat-python
cd weatherhat-python
sudo ./install.sh
```

Pimoroni also recommends installing some extra software for the examples, which you can install with:

```
sudo pip3 install fonts font-manrope pyyaml adafruit-io numpy
```

BOINC – DISTRIBUTED COMPUTING

Scientists all over the world use computers for simulating or analysing data, and some of these projects require a lot of computing power. If you have a Raspberry Pi that is regularly idle and can spare some CPU time, consider lending your power to a scientific effort! Find out more details over at **magpi.cc/boinc.**

SHARING WEATHER DATA

One of the examples with Weather HAT is **adafruit-io.py**, which allows you to store data to Adafruit IO in the cloud. You can also hook your station up to Weather Underground (**wunderground.com**) to be part of a huge network of weather stations that help forecast more accurately and locally.

EQUIPMENT

WEATHER HAT + WEATHER SENSORS KIT

£114 / $121 | magpi.cc/weatherhat

03 Measure the weather

You'll need to set up the wind and rain meters, and SparkFun has a detailed guide on how to this here: **magpi.cc/weatherhookup**. The rest of the sensors that measure temperature, humidity, pressure, and light are on the Weather HAT itself. With the other sensors set up, you can start running some of the examples. In the terminal, use `cd examples` to move into the right directory and then type `python3 weather.py`. This full example makes use of the screen and sensors to show you weather data live from your Raspberry Pi, and may be all you need! Other examples have tips on making use of the various sensors more and you can customise the code to your liking.

SEISMOLOGY WITH RASPBERRY SHAKE

Detect earthquakes and more with this excellent kit

TOP TIP

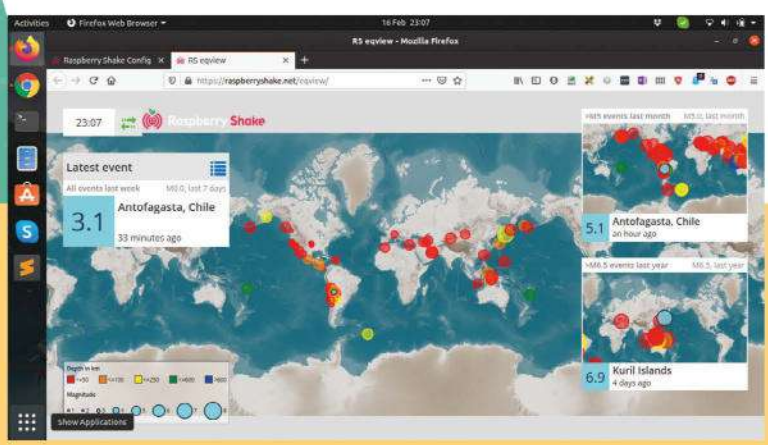
We have a detailed construction guide here: **magpi.cc/makeshake**.

01 Hardware setup

With the DIY kit you have to supply your own Raspberry Pi, and get the geophone wired up to the Raspberry Shake board itself, which needs to be placed on the first 26 pins of Raspberry Pi's GPIO. Seal it inside the enclosure and then make sure it will stand level with a spirit level and the adjustable feet in its desired location.

02 Install software

If you didn't get the Raspberry Shake SD card, download the OS from **magpi.cc/shakeimg** and install it with Raspberry Pi Imager (**magpi.cc/imager**). Plug in the SD card and power up Raspberry Pi, and then head to a browser on another computer and type in **http://rs.local**. The username is **myshake**, while the password is **shakeme** by default, so make sure to change them.



▼ Step 3: Find your station online

EQUIPMENT

RASPBERRY SHAKE

From £136 / $175 | raspberryshake.org

03 Listen for earthquakes

Once all set up, you can start sharing your data to the Raspberry Shake community – exact location is obfuscated so people won't be able to find out where you live. After hitting Forward Data, your Raspberry Shake will restart and you'll be able to see data from your station from the global station view page at **raspberryshake.org**.

SHAKING SCIENCE

We talk to Raspberry Shake founder **Branden Christensen** and marketing director **Mike Hotchkiss** about citizen seismology

What kind of data can people pick up with Raspberry Shake?

Branden: There's two primary data streams you can get from Raspberry Shake, depending on the model. One of them is for measuring Earth's motion. That could be an earthquake, but it could be a person walking, so it spans a wide spectrum. You can measure Earth motion from a magnitude six earthquake from the exact other side of the globe – about 16,000 km away. This motion is finer than the thickness of a human hair.

The other type of sensor is called Raspberry Boom, which is a similar sensor but it measures what's happening in the atmosphere around and above your body. There's been a lot of fun activity in the community with that, measuring explosions, as well as measuring meteors colliding with the atmosphere.

Find live data from your area

What interesting ways have people used Raspberry Shake?

Mike: The world went quiet during Covid, with everyone indoors, shut away. Our network is the largest seismic network in real time around the world and we noticed that the human noise of people walking around, traffic, etc., went quiet. It generated some buzz in our community.

It allowed for seismographs to actually detect more of the Earth's rumble, but on the other side it was fascinating how much noise was reduced, and there was a study done on it in Science (**science.org**).

Branden: There were 72 authors for the paper. 71 of them are professional seismologists... and then there's one person who is listed as a co-author who is a citizen scientist from our community.

> "There's two primary data streams you can get from Raspberry Shake, depending on the model"

Mike: Raspberry Shakes and Booms have also been used in wildlife conservation to study how elephants communicate with each other on the Savannah in Africa.

And also for conservation efforts for the black-footed ferret. A zoo worked alongside seismologists, to try and find new habitats for the ferret. So they set up Raspberry Shakes in various habitat zones, because they're very sensitive to vibrations so, as an endangered species, they want to make sure they were happy.

RASPBERRY SHAKE IN EDUCATION

Education is something Raspberry Pi is great for, and so it's natural that Raspberry Shake would also become an educational resource. Doing experiments with Raspberry Shake and earthquake data can show kids practical uses of science, and there are free resources for teaching available as well. For more info, check out **magpi.cc/shakelearn**.

AMATEUR ASTRONOMY

Search the stars with these astronomy projects

PIKON

If you simply fancy looking at the stars, you can't go far wrong with PiKon – a 3D-printed telescope that makes use of Raspberry Pi Camera and mirrors to create a telescope that costs considerably less than commercial ones. We've seen fantastic close-up photos of the moon using the HQ Camera, and that's just the beginning of what you can do with it.
pikonic.com

RMS METEOR

Using collaboratively written software, RMS (Raspberry Pi Meteor Station) can be hooked up to old CCTV cameras to track meteors through the night sky. The creators are part of UKMON (UK Meteor Network) which can use RMS data to help identify what folks are seeing during the night.
magpi.cc/rms

CHEAP ALL SKY CAMERA

This very cheap and neat build is able to view a lot of the sky looking for meteors thanks to a dedicated piece of software called Meteotux Pi (**meteotuxpi.com**) which takes continuous high-resolution images through a fish-eye lens under a waterproof, clear plastic dome. It can also easily stack star trail photos for some cool results.
magpi.cc/casc

ASTROPHOTOGRAPHY WITH RASPBERRY PI

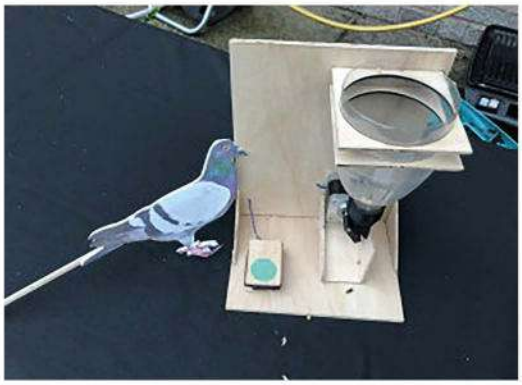
In issue 128 we created a guide on how to use the latest Raspberry Pi Camera Module to take photos of the night sky. From basic photos to star trails, you can read more at **magpi.cc/128**.

NATURE AND CONSERVATION

See what's going on right outside your front door with these builds

RASPBERRY PI CAMERA TRAPS

Last issue we covered several ways of taking photos and video of beasties in your back garden – including even some under the water if you really fancy! Check out **magpi.cc/131**.

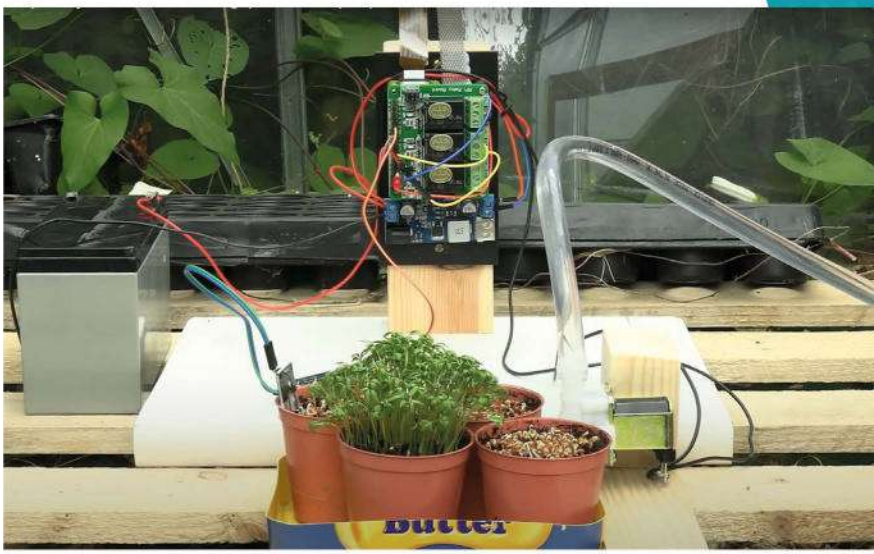


PIGEON PI

Did you know you can teach pigeons? It makes sense, as homing pigeons exist; however, Pi & Chips decided to test this out by creating a feeder that activated with the touch of a button. Would Frank the pigeon be able to figure out the way to get more food? We actually don't know, but you can definitely try it for yourself and your local pigeons.
magpi.cc/pigeonpi

NATUREBYTES WILDLIFE CAM

This full camera trap kit is fairly simple, using motion sensors to take photos and/or video of things moving in its view. Hopefully, this includes birds, hedgehogs, and only minimal humans. Attach a NoIR Camera Module and some IR LEDs and you'll be able to record night-time footage too.
naturebytes.org



PLANT GROWTH TIME-LAPSE

Watering plants and seeing how they grow, this project is great for a flora enthusiast that would love to see how their green baby grows when they're not around. Going over footage, you can also see whether or not it needs a bit more sun or protection from dangerous predators, such as the deadly slug.
magpi.cc/planttimelapse

Kitronik ZIP96 Retro Gamer

SPECS

FEATURES:
12×8 RGB ZIP LED matrix display, 6 × input buttons, piezo buzzer, vibration motor, on/off switch, 3 × breakout headers

POWER:
3 × AA battery holders

DIMENSIONS:
141 × 60 × 24.6 mm

▶ The Pi Hut ▶ **magpi.cc/zip96** ▶ From £36 / $38

Learn to code with this Pico-powered handheld. By **Phil King**

Retro gaming is fun, so how about creating your own old-school games? The ZIP96 offers the opportunity to learn to code and enjoy playing the results on a basic handheld console. It doesn't even have a case, although you could always design and 3D-print one.

The bare-bones PCB features four standard tactile push-buttons for a directional pad on the left, with a couple of action buttons on the right. Between them is not a screen, but a 12×8 LED matrix with addressable RGB pixels. Below this are twin female headers to plug in your Raspberry Pi Pico – one isn't supplied. Between the headers is a tiny piezo buzzer for rudimentary sound (beeps with settable pitch).

On the rear of the board you'll find a vibration motor that spins at high speed to create the kind of rumble effect you get on some commercial games controllers. You'll also find three AA battery holders for portable power – more on that later.

Pico programming

Too basic to stand up as a pure gaming device, the ZIP96 is aimed more at the educational market. For this purpose, there's a series of ten lessons available as downloadable PDFs, taking learners through the fundamentals of object-oriented programming in MicroPython as they create a simple maze game, called the A-Mazing Game. The well-structured, step-by-step lessons cover aspects such as classes, objects, functions, loops, and threads. It's a very good introduction.

As usual, you connect Pico to a computer via USB and use the Thonny IDE to start coding. You'll need to install the ZIP96 MicroPython library, which is available in Thonny's PYPI package manager – just search for it there. This makes it relatively easy to read and trigger the ZIP96's various components by name. The pixels on the LED matrix can be addressed using X and Y co-ordinates or by their ID number, from 0 to 95 (numbered left to right, top to bottom).

In the ZIP96 GitHub repo (**magpi.cc/zip96git**), you'll find files for the A-Mazing Game at various stages of construction, to go with the lessons. There's also a classic Snake game to try out, along

with another code example written in C: a platform game called Run Along, Jump & Jump. There's even a wireless two-player version of the latter for two ZIP96 boards equipped with Pico Ws.

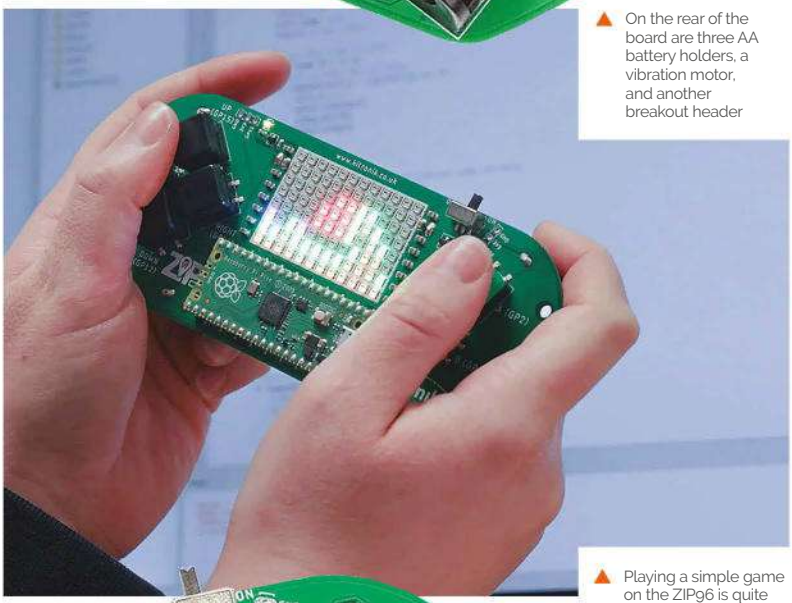
Powering the matrix

One curious feature we came across while coding is that, for some reason, USB power can't be used to run the LED matrix. You need to have AA batteries inserted and the device's slider switch set to on. Not a major issue, although we did mistakenly think we might have a dud unit for a little while. The other downside of this setup is that you can't use just a USB power bank for portable play, which is a shame.

> Too basic to stand up as a pure gaming device, the ZIP96 is aimed more at the educational market

Another issue we encountered was that you need fully charged batteries for the LED matrix to light up in the right colours. With low batteries, we found that the blue element didn't show up, so cyan pixels looked green, for instance.

On the rear of the board are three AA battery holders, a vibration motor, and another breakout header



Playing a simple game on the ZIP96 is quite fun, but it's mainly about learning to code

The ZIP96 doesn't come with a Pico. Two breakout headers at the top enable you to add optional shoulder buttons

Verdict

An interesting and fun educational tool. The simple LED matrix display limits the possibilities for creativity, but does make it easier learn the fundamentals of coding.

7/10

Technaxx TX-207

SPECS

POWER:
Max power 21 W, Max voltage 6 V, Current 3 A Max, Efficiency >19%

DIMENSIONS:
Weight: 0.75 kg, Dimensions: 20 (81 unfolded) × 29 × 3 cm

DESIGN:
Solar panel – monocrystalline solar cell, Operating temperature +10°C~+40°C, Material PET, Plug type 2 × USB-A (3 A max)

▶ Technaxx Germany ▶ **magpi.cc/tx207** ▶ €99/£89/$110

Lucy Hattersley takes Raspberry Pi Zero out in the garden for a test with this solar charging case

We've been interested in running Raspberry Pi from a solar panel, like this Technaxx TX-207, for a while. Many of our projects work outdoors, and it'd be great to power them without the need for running cables. Raspberry Pi devices, especially Raspberry Pi Zero and Pico, are tremendously low-power boards, so theoretically this shouldn't be a problem. There's no shortage of solar panels around, but this option from Technaxx caught our eye, thanks to its widespread availability (you can pick it up from B&Q) and reliable branding. The design is foldable with built-in pockets, and the build quality is excellent with fabric made from PET (polyethylene terephthalate) rather than plastic. Inside one of the pockets is a block with two USB-A ports, which lends itself perfectly to our single-board computer.

▼ Our setup with the TX-207 and FF-017 battery powering Raspberry Pi Zero 2 W

Unfolding the case reveals three solar panels that output 6 V with 3 A (max 21 W) of power. Enough to power a Raspberry Pi Zero or Pico device. We set it up with a Raspberry Pi Zero 2 W in the pocket to test performance. We used a modified version of jbudd's **uptime.sh** code to log the uptime (see this Raspberry Pi forum post: **magpi.cc/uptimesh**). Our Zero 2 W was connected to the local Wi-Fi network so we could log in and check the **uptime.log** file throughout the test. Our first test involved popping a Zero 2 W directly to the USB-A slot in the TX-207 and we hung the charger vertical in a south-facing window. In theory, this sounded good but the TX-207 powered Raspberry Pi Zero 2 W for less than a minute in a whole day. After that, we took it outside and laid it out flat in a garden where it would sporadically power, sometimes for up to six minutes, but our Zero 2 W would frequently drop out along with the sun. Pairing the TX-207 with a USB battery charger was a game-changer. We coupled it up with a Golf GF-017 2600 mAh battery charger (**magpi.cc/gf017**), which held the charge provided by the TX-207 and charged up the battery alongside running Zero 2 W. We started with a completely empty battery charger and our Raspberry Pi Zero 2 W ran up the charge and went for a total of 13 hours and 14 minutes with no downtime.

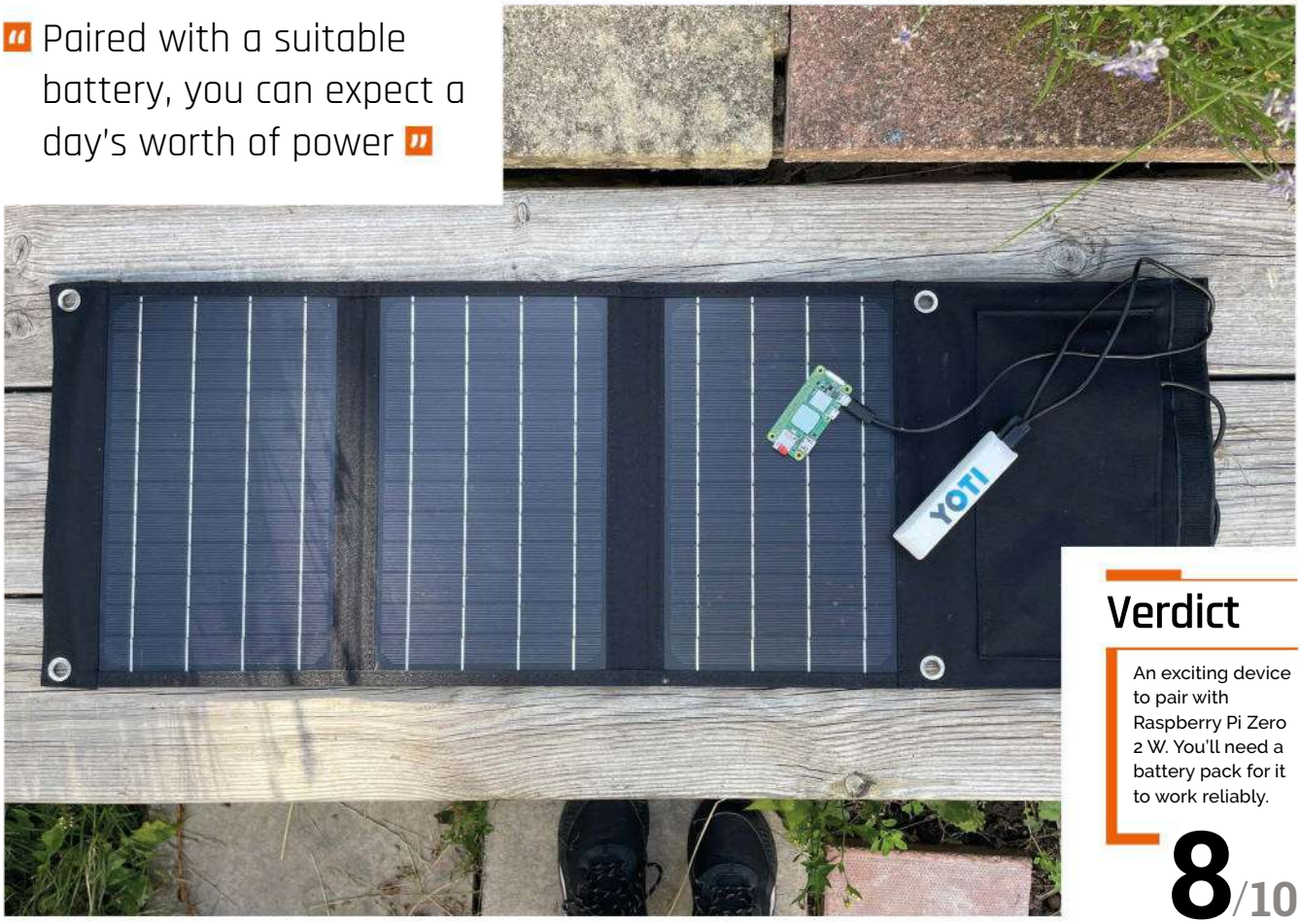
So, paired with a suitable battery, you can expect a day's worth of power from this. More than enough to run scripts and handle low-voltage sensor HATs and other hardware.

It's not listed as waterproof, although it did tip it down one day to no discernible effect. It certainly feels sturdy enough to withstand the elements, as long as you keep an eye on things.

TECHNAXX
GERMANY
21W Solar Ladetasche TX-207
21W Solar Charging Case TX-207
21 Watt Solarpanel für unterwegs /
21 Watt solar panel for on the way
2x USB-A Anschlüsse mit 3 A max. /
2x USB-A port with max. 3 A
Kompaktes Design für jeden Rucksack /
Compact design for all backpacks
21W Solar Ladetasche TX-207
21W Solar Charging Case TX-207
TECHNAXX

- The TX-207 provides a constant drip of power in a well-designed portable case
- You need to pair it with a USB charger for it to be of any real use

> Paired with a suitable battery, you can expect a day's worth of power



Verdict

An exciting device to pair with Raspberry Pi Zero 2 W. You'll need a battery pack for it to work reliably.

8/10

Raspberry Pi Pico Advanced Kit

SPECS

MICROCONTROLLER:
Raspberry Pi Pico or Pico W

COMPONENTS:
Sensors, jumper cables, robot kit, breadboards, LEDs, inputs, hand tools

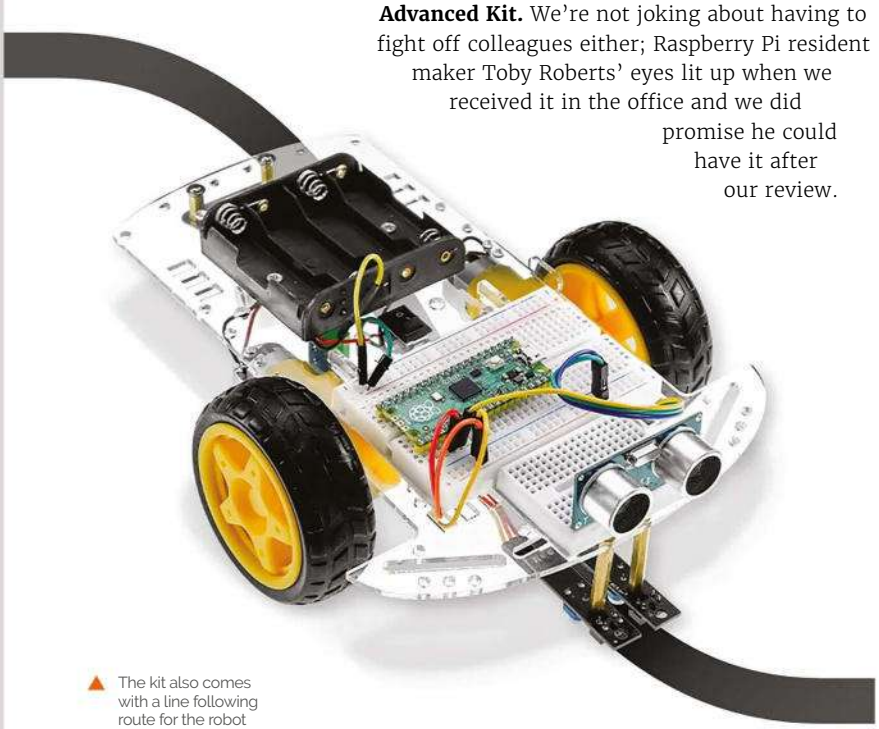
LANGUAGE:
MicroPython

▶ Elecrow ▶ **magpi.cc/advpicokit** ▶ £29 / $38

A box of fun with 32 projects to try out.

Rob Zwetsloot fights off colleagues to test them all

We've looked at and reviewed many an electronic starter kit in the past, but we have never come across something as comprehensive and, frankly, stuffed full of fun components as this Advanced Kit. We're not joking about having to fight off colleagues either; Raspberry Pi resident maker Toby Roberts' eyes lit up when we received it in the office and we did promise he could have it after our review.



▲ The kit also comes with a line following route for the robot

Unfortunately, we may have to break that promise (sorry Toby) as, frankly, you could not ask for a better box stuffed with little electronics to satiate just about any Pico project idea you could have. The box says it has 32 different kinds of components which encompasses a wide range of sensors, inputs, outputs, and even a robot kit. We suggest you take a look at the website for the full list as it is astonishing – especially at the price.

This kit also has 32 guides from Elecrow with things you can make with the components using the more standard MicroPython language on Pico – and credit to the team, there's not a huge amount of overlap with the types of projects as well.

Advanced learning

Despite being called an Advanced Kit, it does let you start from the very basics – getting your Pico to blink its own LED. Then other LEDs. Then switches. Before you know it, you're measuring distances with ultrasonic sensors, creating Catherine Zeta Jones-style laser traps, and even building a robot arm. The difficulty curve for the projects is fairly good, and tutorials will concisely explain how different components work to better your understanding.

At the end of the book you'll build a robot and program it, but it really doesn't stop there.

A look at the components that come crammed into the box

Instructions include photos for building and in-depth info on parts

With all the different things you've made, it's very easy to get ideas to create new projects or combine other ones to extend their functionality.

> With the price and number of components, this really is one of the best ways to help a curious maker learn a ton about electronics

Much like this magazine, the guides list the code example and allow you to download it separately in case you need to check it (or just don't feel like typing it up from scratch).

With the price and number of components, this really is one of the best ways to help a curious maker learn a ton about electronics, Pico, and coding. You could even upgrade a lot of the projects with a full Raspberry Pi. It's something we're definitely keeping close to us for future projects, although we may need to make a Toby Sensor using parts from the box to keep it safe.

ELECROW
Lesson 16: Servo control
1.Servo:
The 9g small servo is a position (angle) servo driver, suitable for those control systems that require the angle to change continuously and can be maintained. Common in model aircraft, aircraft models, remote control robots and mechanical parts. In use, the accessories of the servo usually include a bracket that can fix the servo to the base and a rudder plate that can be sleeved on the drive shaft. Through the holes on the rudder plate, other objects can be connected to form a transmission model.
2.Project Introduction:
Control the servo to rotate back and forth through the Pico.

Verdict

Packed full of projects at a very reasonable price, this starter kit will follow even an experienced maker around.

10/10

Cosmic Unicorn (Pico W Aboard)

SPECS

DISPLAY:
32×32 matrix of RGB LEDs (1024 in total)

FEATURES:
Pico W on board, 10 × push-buttons, mono I2S amp and 1W speaker, 2 × Qwiic/STEMMA ports, battery connector, 2 × metal legs

DIMENSIONS:
204 × 204 mm

▶ Pimoroni ▶ **magpi.cc/cosmic** ▶ £80 / $82

A big, bright, and beautiful LED matrix display. By **Phil King**

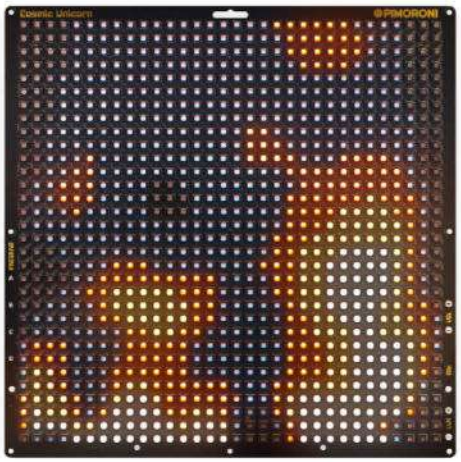
We thought the Galactic Unicorn (reviewed in issue 126, magpi.cc/126) was impressive, but the Cosmic Unicorn is its bigger stellar sibling. This super-size display has 1024 addressable RGB LEDs in a square 32×32 grid.

The Pico W pre-soldered to the rear means you've got Wi-Fi connectivity baked in, along with Bluetooth – as used in our music visualiser tutorial in issue 129 (**magpi.cc/129**).

As with the Galactic Unicorn, it comes preloaded with Pimoroni's own brand of Pico MicroPython firmware and an auto-running demo program that lets you press one of four tactile buttons to choose from four graphical effects: burning flames, eighties supercomputer (random pixels), cycling rainbow, and nostalgia computer prompt.

> This super-size display has 1024 addressable RGB LEDs in a square 32×32 grid

▶ It's powered by a Pico W soldered on the rear, where you'll also find a speaker, buttons, battery connector, and Qwiic/STEMMA ports



▲ Animated flames, one of four demo effects, show off the graphical power of the Cosmic Unicorn

Again, the Pico W RP2040's PIO state machines are used – along with 12 FM6047 constant current LED drivers – to control the 3.5mm pixels at around 300fps at 14-bit resolution, so there's no sign of any flicker.

Sounds good

At the rear you'll find a small 1W audio speaker along with two Qwiic/STEMMA ports (JST-SH) for connecting breakouts such as sensors. There's also a battery connector (up to 5.5V). Positioned at the right-hand edge of the front is a phototransistor to detect light levels. Two metal legs are supplied to use as a stand.

Programming is relatively simple using the PicoGraphics library for shapes, sprites, and a selection of fonts. Check out the full function list in the Cosmic Unicorn MicroPython reference guide: **magpi.cc/cosmicref**. Inspiration can be found in several code examples, including a neat web-server-based paint program for drawing on the display from a computer.

Verdict

The larger display area opens up more possibilities for projects, such as a weather dashboard, as well as for playing impressive graphical effects and animations.

9/10

Astradis Elektronik is Raspberry Pi's distributor for the industry

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Inky Frame 7.3″ (Pico W Aboard)

SPECS

DISPLAY:
7.3-inch e-ink, 800×480 pixels, seven colours

FEATURES:
Pico W, 5 × user buttons, reset button, LEDs, microSD card slot, breakout header, 2 × Qwiic/STEMMA QT ports, 2 × metal legs

DIMENSIONS:
176.2 × 139.2 mm

Pimoroni | **magpi.cc/inkyframe7** | £90 / $93

Powered by Pico W, this is one big-screen e-ink display. By **Phil King**

The 800×480 widescreen display can render dithered colour images with a fair amount of detail

The Inky Frame 7.3″ is the big daddy of e-ink displays, offering a usable area of 160mm by 96mm – a widescreen aspect ratio of 1.67:1. With an 800×480 resolution, that gives a pixel density of 127.8 PPI; while notably lower than the 188.7 on its Inky Frame 4.0″ smaller sibling, it's perfectly adequate in practice.

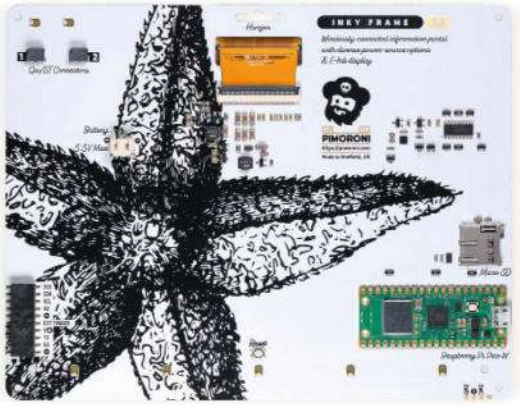
> The on-board real-time clock can place Pico into an ultra-deep sleep mode

Other than that, it's very similar in design to the previous Inky Frame models, with a seven-colour e-ink display with five tactile user buttons underneath. It's based around a standard Raspberry Pi Pico W board pre-soldered to the rear of the board, so you can connect it to a computer via USB for programming, as usual. The rear also features two Qwiic/STEMMA QT ports (for attaching breakouts) and an extension header (including six GPIOs), along with a reset button, microSD card slot (extra storage for images etc.), and JST battery connector.

Slow but ultra-efficient

Like other e-ink displays, the Inky Frame 7.3″ takes a while to refresh the screen: typically 25–30 seconds – a little longer if rendering JPG images. The big advantage is its ultra-low power drain: e-paper only uses power while refreshing. As well as keeping time, the on-board real-time clock can place Pico into an ultra-deep sleep mode that uses a tiny 20 µA until woken.

Software-wise, it's preloaded with Pimoroni's MicroPython firmware, including the PicoGraphics display library and several code examples. To connect Pico W to your wireless network, just fill in the SSID and password in the **secrets.py** file – see the Getting Started guide (**magpi.cc/inkyframeguide**) for more details.



On the rear you'll find a Pico W, along with a microSD card slot, reset button, and external connectors

Verdict

All the low-power advantages of colour e-ink combined with larger screen estate makes this a formidable display.

9/10

10 Amazing:

Upcycling projects

Reduce, reuse, and recycle with these upcycled Raspberry Pi projects

Old tech will always be cool. A mix of nostalgia and forgotten design concepts will forever make something appealing to the right person. Sometimes though, the technology behind them can be hard to keep using – this is where our favourite tiny computer comes in to modernise.

Old School Minitel Laptop

Terminal to desktop

These French terminals connected to a country-wide network that allowed you to book train tickets, check email, access banking, and other digital services we take for granted now. Now, it's a laptop.

magpi.cc/minitel

Thermal Paper Polaroid

Snapshot

Instant cameras are making a comeback, but what if you could combine newer photography tech with them? Well, this is your answer.

magpi.cc/thermpola

Magic mirror dresser

Victorian upcycling

Magic mirrors are classic and cool Raspberry Pi projects – this adds a lot more flare by being integrated into a whole antique dresser.

magpi.cc/dresser

Repurposed Wii U

Emulation station

When you have a broken console – or (unfortunately) obsolete console – you can turn it into a pretty great handheld emulator with a Raspberry Pi.

magpi.cc/emuwiiu

Boost-Box 0.1

Super Super-8

Once a way to view film footage from your home camera, now it's a command line YouTube browser for a very cool and retro way to watch Funny Vine Compilations 16.

magpi.cc/super8

Tomy Turnin' Turbo Dashboard Arcade

Magical sound shower

This is a forever-cool update of a kids' toy from the eighties to run classic arcade game Out Run, and is full of rad extra features like a working speedometer and revs.

magpi.cc/outrun

Digital Consult Dash

Pee-OBD-II adaptation

OBD-II is a standard that makes connecting Raspberry Pi to a car very easy. What happens when you have to use an old consult system? Meet Consult Dash.

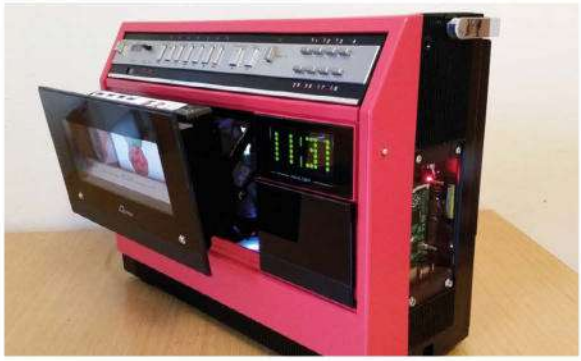
magpi.cc/consultdash

Alexa Ruxpin

Teddy.AI

Although this seems like the start of a nineties horror movie, this really project makes a classic talking teddy a little smarter. Maybe too smart.

magpi.cc/alexaruxpin



1981 Portable VCR Raspberry Pi Media Centre

Be kind, rewind

Physical chunky buttons will always be great and popping out the fake cassette to access a USB hub is very cool too. Also, it works as a media centre.

magpi.cc/vcrmc

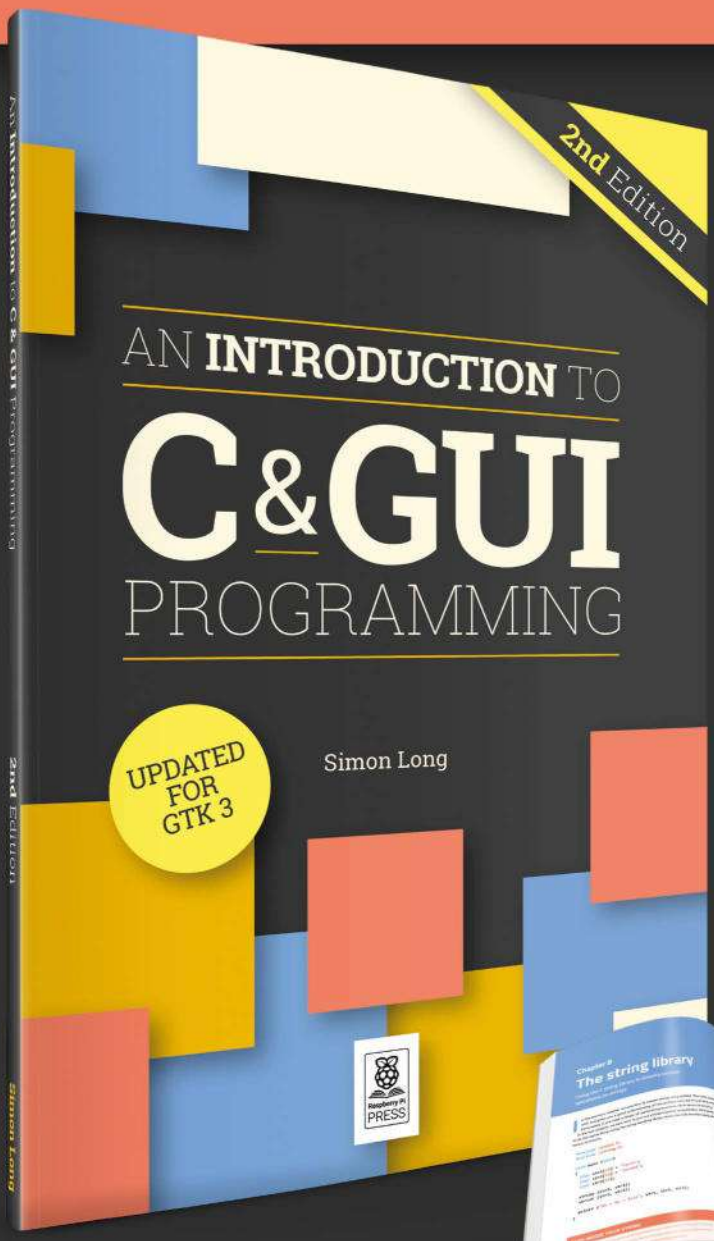
Converted joystick

Pico-powered USB

Did you experience the pain of having to replace a serial joystick? Well if you waited another 20 years, you could have installed a Raspberry Pi Pico and converted it to USB!

magpi.cc/picojoystick

AN INTRODUCTION TO C&GUI PROGRAMMING



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By **Lucy Hattersley**

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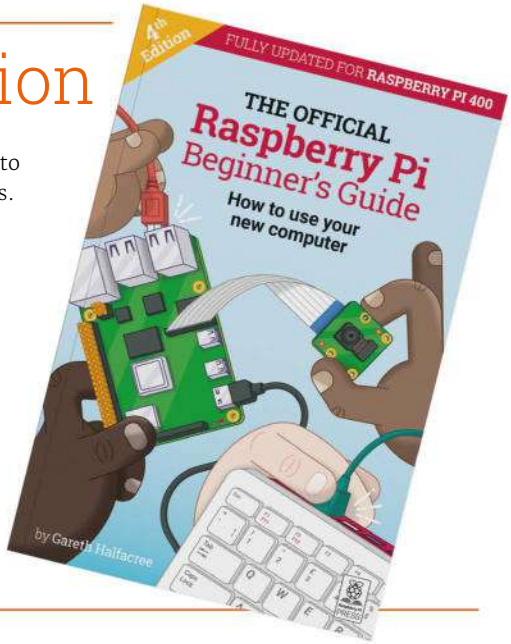
£10/$14

magpi.cc/beginnersguide

The Raspberry Pi Beginner's Guide is a 252-page guide to using our single-board computer. Once you get past the initial setup process, the book dives straight into a friendly guide to learning coding with Scratch and Python programming languages.

Designed for absolute beginners, the book shows you how to use the Thonny coding environment to create basic text-based programs and techniques such as looping, conditions, and variables and using turtle drawing to learn logic techniques. It then works toward creating a spot-the-difference game by importing images, and role-playing adventure games. On the whole, it's an extremely friendly way to discover Python coding on Raspberry Pi.



Bookmark these

Here are three websites you should bookmark when learning Python

PYTHON CHEATSHEET

This website is a one-page reference for Python 3 programming language. It has quickstart links and example code for common techniques.

quickref.me/python.html

PYTHON 3.11.4 DOCUMENTATION

The official documentation page for the Python programming language. As well as offering tutorials and reference materials, it includes a huge range of in-depth information about the syntax of the programming language.

docs.python.org/3/

PEP 8

The style guide for Python coding gives detailed examples of coding conventions. Having it to hand when coding can improve the legibility of your code, and help you be a more consistent programmer.

peps.python.org/pep-0008/

The Complete Python Bootcamp From Zero to Hero in Python

AUTHOR

Jose Portilla

Price:
£13/$30

magpi.cc/pythonbootcampudemy

If you prefer learning from a video course, then check out this Udemy boot camp by Jose Portilla.

The Complete Python Bootcamp From Zero to Hero in Python starts with the basics of programming and moves all the way up to web development and data science. The course is more detailed than the other options listed here. After covering the basics, up to and including object-oriented programming and modules, it moves on to advanced subjects such as Python Decorators and Generators. It also has a number of practical exercises including web scraping, image manipulation, working with PDFs and spreadsheets, and creating GUI interfaces with Jupyter Notebook.

Although not specifically for Raspberry Pi, it's one of the most detailed Python courses around and is packed with good advice.

Computing Courses

AUTHOR

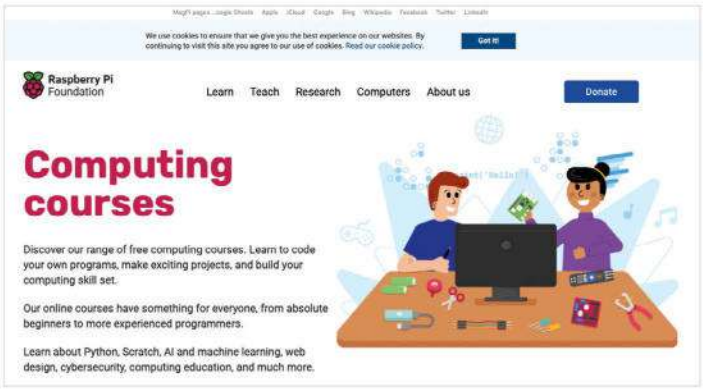
Raspberry Pi Foundation

Price:
FREE

magpi.cc/computingcourses

If you're looking to pick up computing skills, then it makes sense to head straight to Raspberry Pi Foundation's Computing Courses. Here you can pick up skills in Python including basic programming, computational thinking, data structures, creating apps with GUIs (graphical user interfaces), and all the way up to networking and physical computing with electronics.

One of the many great things about these courses is that they fit with the computing curriculum, so you can be sure it's created by specialist educators and that the skills you learn are going to be useful.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Computing courses
Discover our range of free computing courses. Learn to code your own programs, make exciting projects, and build your computing skill set.
Our online courses have something for everyone, from absolute beginners to more experienced programmers.
Learn about Python, Scratch, AI and machine learning, web design, cybersecurity, computing education, and much more.

Get immersive

Surround yourself with Python people

TALK PYTHON TO ME

Listen to all things Python with this podcast that interviews coders and discusses how Python is used in the real world.

▶ talkpython.fm

REDDIT

The /r/learnpython subreddit is a great place to find new and popular resources along with other learners.

▶ reddit.com/r/learnpython

OFFICIAL FORUM

The official Python form is a great place to ask for help, share ideas, and learn more about Python from the experts.

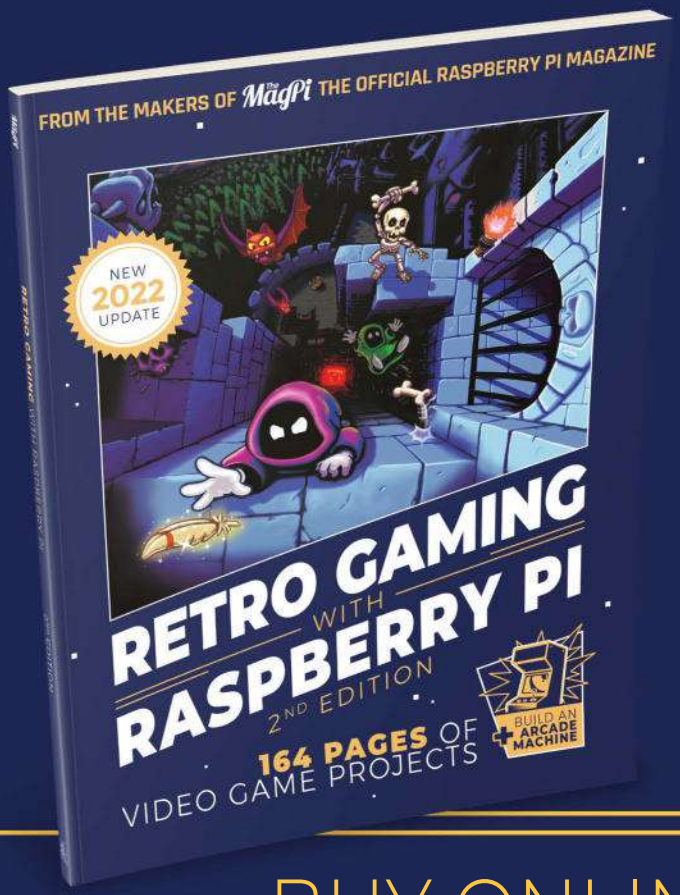
▶ discuss.python.org

RETRO GAMING WITH RASPBERRY PI

2ND EDITION

Retro Gaming with Raspberry Pi shows you how to set up a Raspberry Pi to play classic games. Build your own games console or full-size arcade cabinet, install emulation software and download classic arcade games with our step-by-step guides. Want to make games? Learn how to code your own with Python and Pygame Zero.

- *Set up Raspberry Pi for retro gaming*
- *Emulate classic computers and consoles*
- *Learn to code your own retro-style games*
- *Build a console, handheld, and full-size arcade machine*


FROM THE MAKERS OF The MagPi THE OFFICIAL RASPBERRY PI MAGAZINE
NEW 2022 UPDATE
RETRO GAMING WITH RASPBERRY PI
2ND EDITION
164 PAGES OF VIDEO GAME PROJECTS
+ BUILD AN ARCADE MACHINE

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01

Liverpool MakeFest 2023

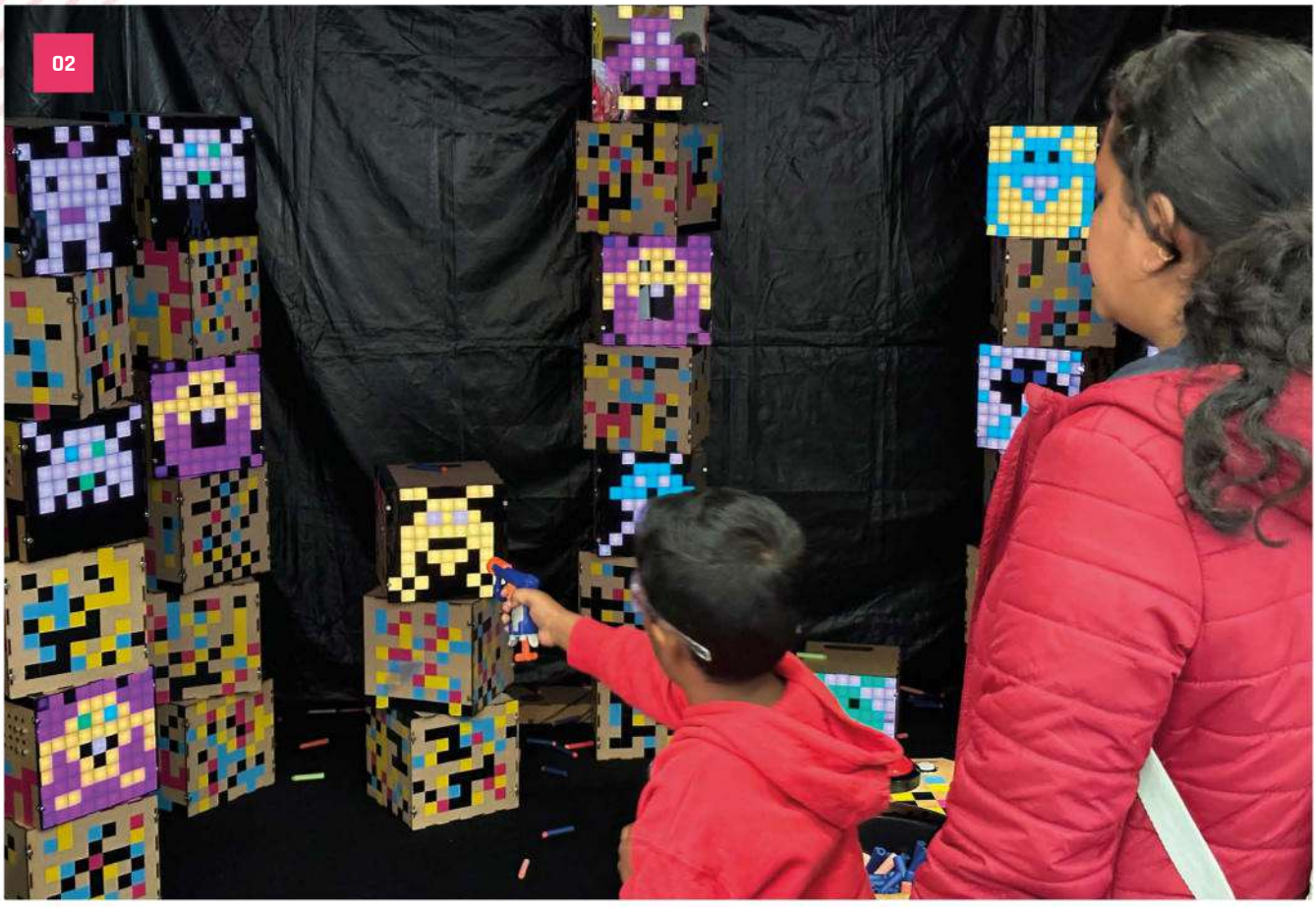
Roving *The MagPi* reporter PJ Evans heads to Merseyside to see displays of Raspberry Pi greatness

Set in the beautiful Central Library, Liverpool MakeFest is a free event that brings makers together from all over the country to enthuse about their creations, projects, and art. Naturally, many a Raspberry Pi could be found lurking in the various builds, robots, and displays that peppered four floors of the building. After a smaller event last year, there was more to see and do this time, including new features such as spoken poetry.

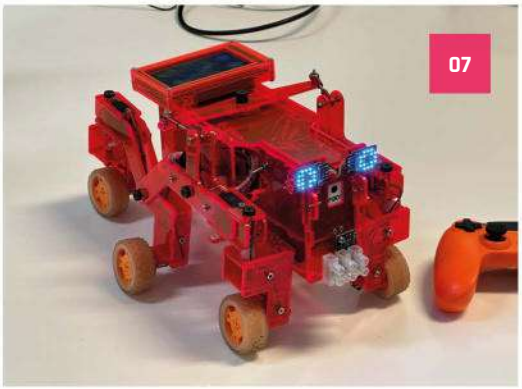
For Raspberry Pi fans, there were some impressive things to see. Brian Corteill, very much the Roy Kent of Raspberry Pi events (he's here, he's there…), brought Zoe, his huge e-ink Zoetrope. Children and adults alike delighted in seeing their animations come to life. Another veteran of the scene, Dr Footleg, demonstrated his latest robotics projects, and Extreme Electronics showed their pretty Pico Cray and their new Picoputer, a tiny terminal capable of running CP/M, likely to be available in kit form later this year. The largest Raspberry Pi–powered exhibit by far was Made Invaders, a physical game that echoes the shooting galleries of the old arcades, but with a modern twist.

> "Naturally, many a Raspberry Pi could be found lurking in the various builds"

The event is another triumph for DoES Liverpool and we very much look forward to being back next year.



01. Getting busier as the day goes on
02. Made Invaders is a cross-over between Space Invaders and traditional shooting galleries
03. Dr Footleg has robots if you have coin
04. Extreme Electronic's new Pico-Puter - CP/M on a Pico!



05. The stunning modern Central Library in Liverpool

06. Event favourites Faceplate, Doofus, and Evil Babbage!

07. Dr Footleg's Pi Wars Entrant

08. Brian Corteil's incredible e-ink Zoetrope

09. The lower floor has a geek's paradise

10. A homemade arcade cabinet powered by Raspberry Pi

11. A behind-the-scenes look at the Pico Cray

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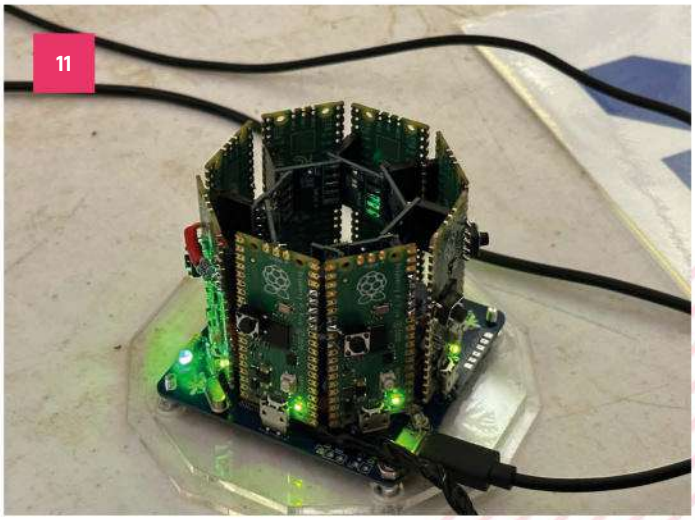
MXDORM
LITTLE VINTAGE PHOTOGRAPHY
FILM & DARKROOM EDUCATION & WORKSHOPS
information

09

Read
PUSH START

10



11

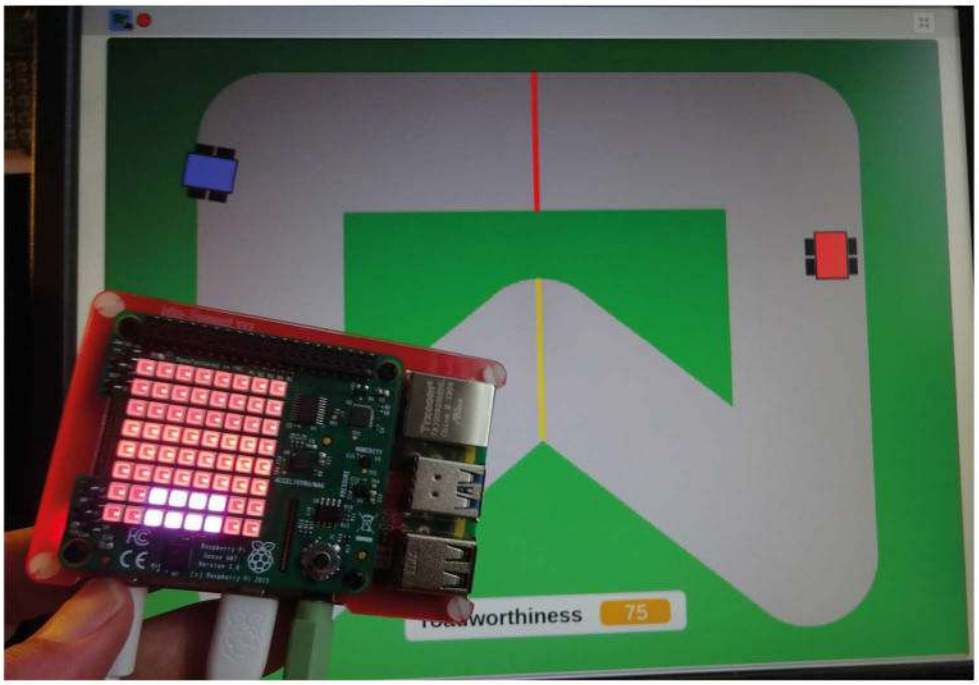
Sean McManus

The MagPi regular and Raspberry Pi guide writer, **Sean** has done just about everything with a Raspberry Pi

- Name Sean McManus | Occupation Writer
- Community role Resource creator | URL sean.co.uk

If you've been reading *The MagPi* for a while, you'll have seen many excellent tutorials from the pen (keyboard?) of Sean McManus. Writing tutorials about games, image manipulation, Scratch stuff, AI storybooks, and much more, there's a reason he's also one of the writers behind *Raspberry Pi for Dummies*.

"I tend to make educational projects, from which readers can learn something about programming," Sean says to us. "I started in the 1980s, writing programs on the Amstrad CPC 464. Some appeared as listings in magazines, including a sprite toolkit that retro developers still use sometimes. I lost touch with programming as a hobby for a few years, but the Raspberry Pi reawakened my interest and made it easy to get back into. I learned Scratch, Python, and Sonic Pi with it, and built some simple electronics projects."



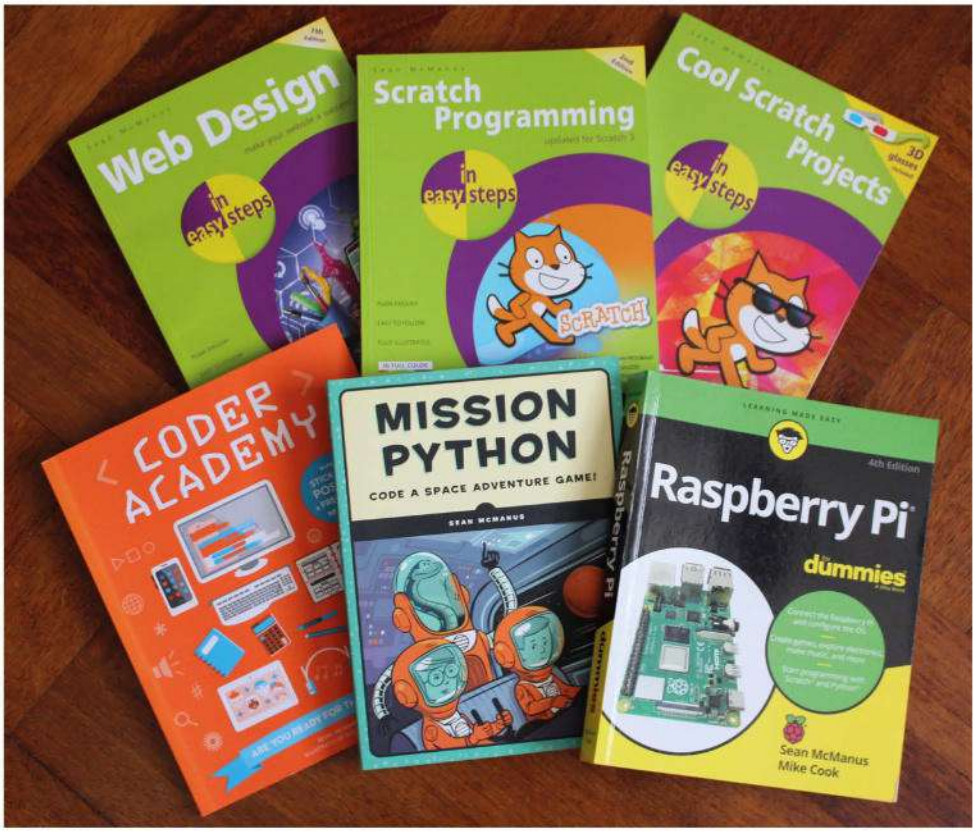
This Sense HAT-controlled racing game is a great way to learn how Sense HAT works

When did you learn about Raspberry Pi?

There was a bit of a buzz online about Raspberry Pi before it launched. I was one of the people who ordered stickers to support the project before the first model went on sale. I ordered a Raspberry Pi Model B as soon as I could, and attended a talk at Google Campus in 2012 where I asked Eben to sign the box (which I still have). The early machines were excellent value and great to experiment with. It's been amazing to see how the performance has increased over the years.

How did you start writing about Raspberry Pi?

In the early days of the Raspberry Pi there wasn't the ecosystem that exists today, and the software wasn't quite as friendly as it is now, either. Friends told me they'd bought a Raspberry Pi computer but didn't really know how to use it, or what to do with it. I had been writing books for Wiley's Older and Wiser series, so I pitched the idea of a Raspberry Pi book, which ended up becoming



Just some of the books Sean has written

Raspberry Pi For Dummies, co-written with Mike Cook. It was one of the first books about Raspberry Pi, and is now in its fourth edition.

What is your favourite thing to write about related to Raspberry Pi?

I like creating projects that people can easily customise or learn from. ArtEvolver (*The MagPi* 119 **magpi.cc/119**), for example, enables anyone to make their own digital artwork by simply curating the images they feed it. Similarly, people can personalise Raspberry Radio (*The MagPi* 122 **magpi.cc/122**) with their own music and DJ banter. My book *Mission Python* featured a space game where readers can modify the maps and puzzles. The idea is to provide an easy way in for people to start tinkering and creating something unique. At the same time, those who want to do more with the code can find Python functions to do things like download RSS feeds, implement computer speech, or index a folder of files. I hope people see bits of my code and think: 'Aha! I can use that!'

> In the early days of the Raspberry Pi there wasn't the ecosystem that exists today

What are some of your favourite projects that you've made with Raspberry Pi?

I enjoyed building the graphic adventure game Escape, which featured in the book *Mission Python*. It shows readers how to go beyond small examples in Python to build a more substantial game. I love Scratch, and one of my favourite projects is Throttle and Tilt. It's a car racing game I wrote to showcase the new features in Scratch 3 (*The MagPi* 86 **magpi.cc/86**). You use a Sense HAT as a steering wheel. I created a few Scratch projects that work with 3D red/cyan glasses, where the depth is part of the gameplay (**magpi.cc/angryaliens**). In 12 Angry Aliens, the aliens fly towards you out of the screen.

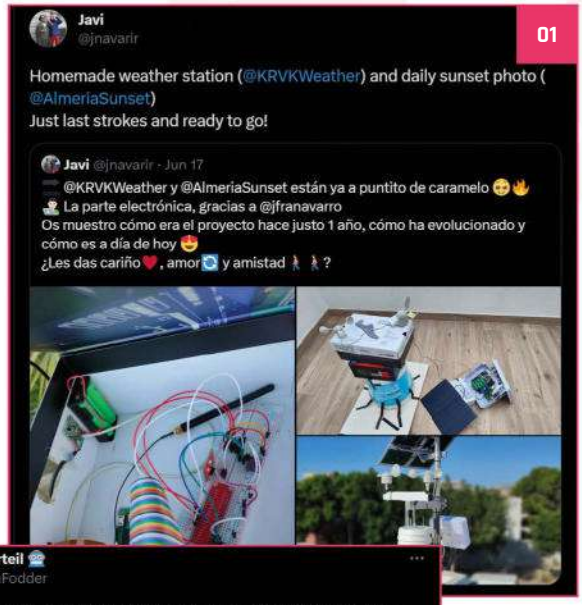
ArtEvolver was a great recent series by Sean, showing you ways to edit photos using code

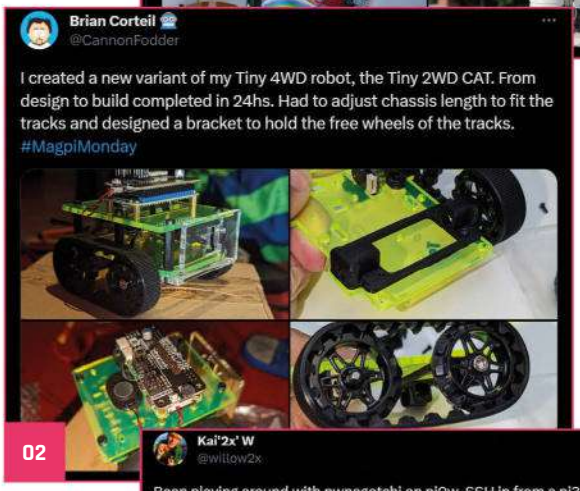
MagPi Monday

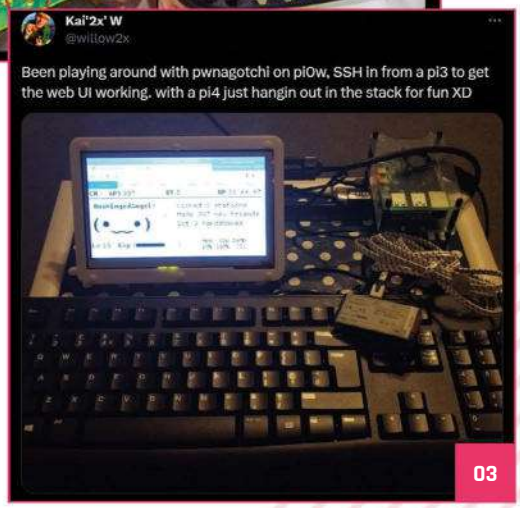
Amazing projects direct from our Twitter!

Every Monday we ask the question: have you made something with a Raspberry Pi over the weekend? Every Monday, our followers send us amazing photos and videos of the things they have made.

Here's a selection of some of the awesome things we got sent this month – and remember to follow along at the hashtag #MagPiMonday!


Javi
@jnavarlr
01
Homemade weather station (@KRVKWeather) and daily sunset photo (@AlmeriaSunset)
Just last strokes and ready to go!
Javi @jnavarlr · Jun 17
@KRVKWeather y @AlmeriaSunset están ya a puntito de caramelo
La parte electrónica, gracias a @jfranavarro
Os muestro cómo era el proyecto hace justo 1 año, cómo ha evolucionado y cómo es a día de hoy
¿Les das cariño, amor y amistad ?


Brian Corteil
@CannonFodder
I created a new variant of my Tiny 4WD robot, the Tiny 2WD CAT. From design to build completed in 24hs. Had to adjust chassis length to fit the tracks and designed a bracket to hold the free wheels of the tracks.
#MagpiMonday
02


Kai'2x' W
@willow2x
Been playing around with pwnagotchi on pi0w, SSH in from a pi3 to get the web UI working. with a pi4 just hangin out in the stack for fun XD
03

01. Learn more about homemade weather stations in our citizen science feature
02. Caterpillar treads make all robots cooler
03. Need to test your network security? Pwnagotchi has you covered
04. Kevin with more robots!
05. Raspberry Pi learning is a global thing
06. Mole Bop was in issue 131 of this magazine
07. That's a lot of robots for people to play with
08. Well these are certainly cool – the button controls are great too
09. We've yet to scan someone's plant, but there's a first time for everything

04

Kevin McAleer Robot Maker
@kevsmac

Happy #MagPiMonday!
This weekend I published the second part of the Master GPIO with @Raspberry_Pi Pico & #MicroPython video series and also played with a Compute Module 4 powered Robot Dog from @elecfreaks!

youtu.be/NlybkEO_2iU

#STEM #robotics #Elecfreaks

05

Roland Schulz r_schulz_maker@mastodon.social
@r_schulz_maker

Good Morning #MagPiMonday, @kevsmac meets german computer science class today. But he still has no idea about it. Get started with @Raspberry_Pi pico and #micropython . Check out his courses to learn programming with #python. It is great!

kevsrobots.com/learn/micropyt...

06

Stewart Watkiss
@stewartwatkiss

This weekend I created a video showing Mole Bop in action. A Pico based game I created for a tutorial for this month's @TheMagPi

penguintutor.com/projects/moleb...

#MagPiMonday

07

Dr Footleg - Roboteer @drfootleg@fosstodon.org
@drfootleg

Nat and I took all the robots to show and let the public drive at #LivMF23 this weekend. #MagPiMonday
That little tracked robot with the Inventor HAT mini is my latest design, finished last week.

08

Erik Nauman
@openblackboard

My high schoolers made mycelium lamps with #RaspberryPiPico boards controlling @adafruit neopixel rings!

09

Pater Practicus
@PaterPracticus

Been sticking more #NFC tags on my projects, so if visitors are intrigued they can easily find the build video on youtube.com/@paterpracticus - youtu.be/-UjNNdQtsy4 #MagPiMonday

Events in pictures: Raspberry Jam Mexico

Community and official events in the wild

As you can see from our events map, wherever you are, there is usually some kind of maker event you can go to. Like Raspberry Jam Mexico – as seen in the pictures captured on this page!

01. The event attracted loads of people of all ages
02. Talks were given in view of demo stations
03. This WALL-E recreation keeps your succulents healthy
04. We spy some fantastic books from some very attractive publishers

FIND OUT ABOUT NEXT MONTH'S EVENTS AND POP-UP ON PAGE 92

Crowdfund **this!**

Raspberry Pi projects you can crowdfund this month

8 Thermocouples DAQ

"The board can read thermocouples type J, K, T, N, E, B, R, and S, thus covering a very large temperature range. The compensation for the thermocouple type is done in software. Thermocouples of multiple types can be mixed and matched on the same board, providing complete flexibility for the user."

▶ **kck.st/3Nqi6Ji**

GPS 4G HAT

"The GPS 4G HAT is an expansion board for the Raspberry Pi. Besides the recording of GPS positions, the product allows transmitting data via 4G and to detect motion by means of the integrated motion sensor. Furthermore, the GPS 4G HAT provides additional input and output connections."

▶ **kck.st/3O17LVM**

Expand your Raspberry Pi

Stackable expansion boards for Raspberry Pi

RS485 Pi

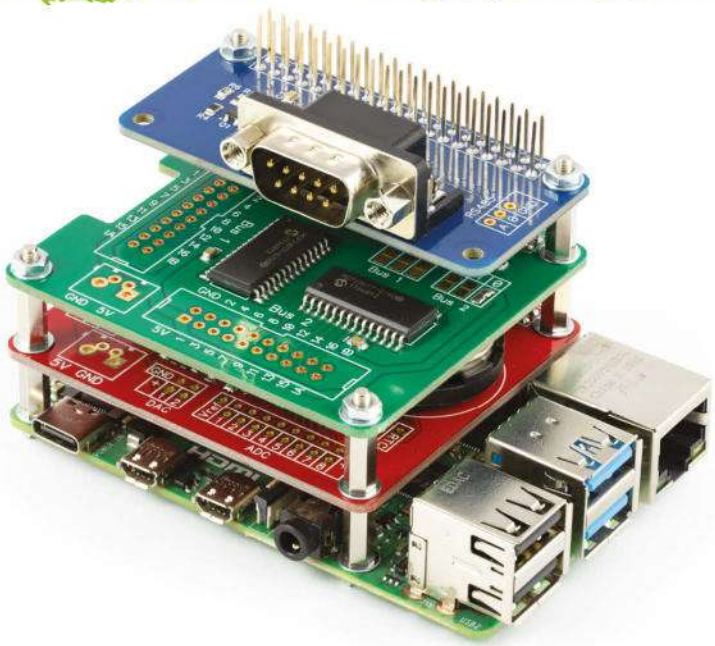
RS485 serial communication board.

IO Pi Plus

32 channel digital I/O controller.

Expander Pi

16 digital I/O channels, 8 analogue inputs, 2 analogue outputs and a real-time clock.



ABelectronics UK

www.abelectronics.co.uk

Your Letters

Bluetooth on Pico

I read that Bluetooth support has come to Raspberry Pi Pico – is this on all versions of Pico, or do I need to get a new one? I didn't know it could even do Bluetooth, have people not been able to get it working before?

Maya via email

If you have a Raspberry Pi Pico W, you now have Bluetooth! It was a function of the wireless chip on the board, but it just took a while to get the firmware and software working properly – it was something that had to be built into the base software itself. Just update to the latest version of MicroPython or C for your Pico W and you'll get access to it.

▲ You can now unleash the full power of Raspberry Pi Pico W

▼ The older Sailing Pi project could likely be converted to something more real time

Tracked sailing

Has anyone done a boat GPS project with a Raspberry Pi?

adeibiza via Twitter

While it's a bit of an older project, there is a tutorial in issue 59 (**magpi.cc/59**) that does just this – although it does only give you the information once you've come back to shore.

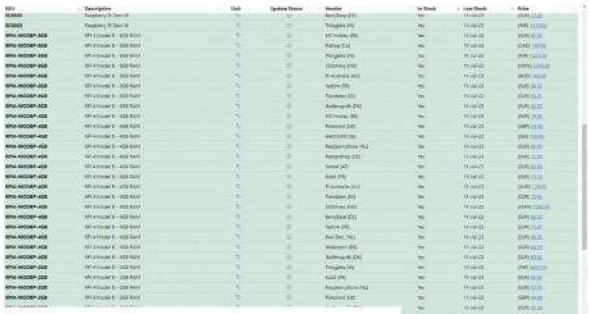
There are real time GPS tracker projects that make use of Raspberry Pi too. However, we assume you would need some kind of mobile data connection to get a decent live location while you're out on the water – there are some 4G LTE dongles that allow for that though.

Getting in stock

I've noticed that Raspberry Pi is coming down in price again – are the scalpers being stopped at the source, or are Raspberry Pis becoming more available again? I've been waiting patiently, so wondering if it's finally time to get some Raspberry Pis.

Ryan via email

In Eben's availability update, he did say that Raspberry Pi stock would start recovering by the end of Q2 and, now we're in the start of Q3, the effects can be seen all over! Not only is it easier to get a Raspberry Pi from Approved Resellers, other places are coming down to more normal prices too. Happy Raspberry Pi hunting!



We like seeing all this green on **rpilocator.com**

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- Online **forums.raspberrypi.com**

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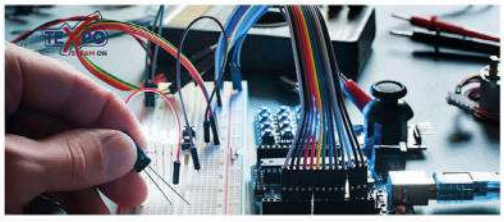
Community Events Calendar

Find out what community-organised Raspberry Pi-themed events are happening near you...



01. Physical Computing with Raspberry Pi Pico Micro-Training

Tuesday 1 August
St George's College, Harare, Zimbabwe
magpi.cc/picomicro

Introducing the Raspberry Pi Pico range of products, this micro training equips participants with the knowledge needed to begin using Pico effectively and building projects with Pico. By the end of this session, participants will be able to setup a Pico and write code using MicroPython to operate a Pico.

02. Small Satellite Conference

Saturday 5 August to Thursday 10 August
Utah State University, Logan, UT, USA
magpi.cc/ssc23

Members of the Raspberry Pi team will be at the 37th annual Small Satellite Conference, which Raspberry Pi are proud to sponsor. The conference explores future missions and delves into key technological drivers, operational constructs, and activities that inform and secure the success of small satellite missions at scale.

03. Melbourne Raspberry Pi Meetup

Sunday 6 August
Docklands Makerspace and Library, Melbourne, AUS
magpi.cc/mrpm132

This meetup is open to everyone with an interest in electronics, robotics, home automation, 3D printing, laser cutting, amateur radio, high altitude balloons, space tech, etc. Makers are invited to bring along their projects and project ideas, and come connect with other makers. Get your questions answered, show off the work you are doing, and get support to resolve nagging issues.

04. Riverside Raspberry

Monday 14 August
3600 Lime Street, Riverside, CA, USA
magpi.cc/riverside132

Riverside Raspberry is a California-based enthusiast group that's been meeting up for almost a decade. This group will appeal to thinkers and tinkerers, the scientifically curious, software developers looking to get into embedded development, or anyone young or old that has a knack for tech in general.

FULL CALENDAR

Get a full list of upcoming community events here:

magpi.cc/events

RASPBERRY PI AT MAKER FAIRE

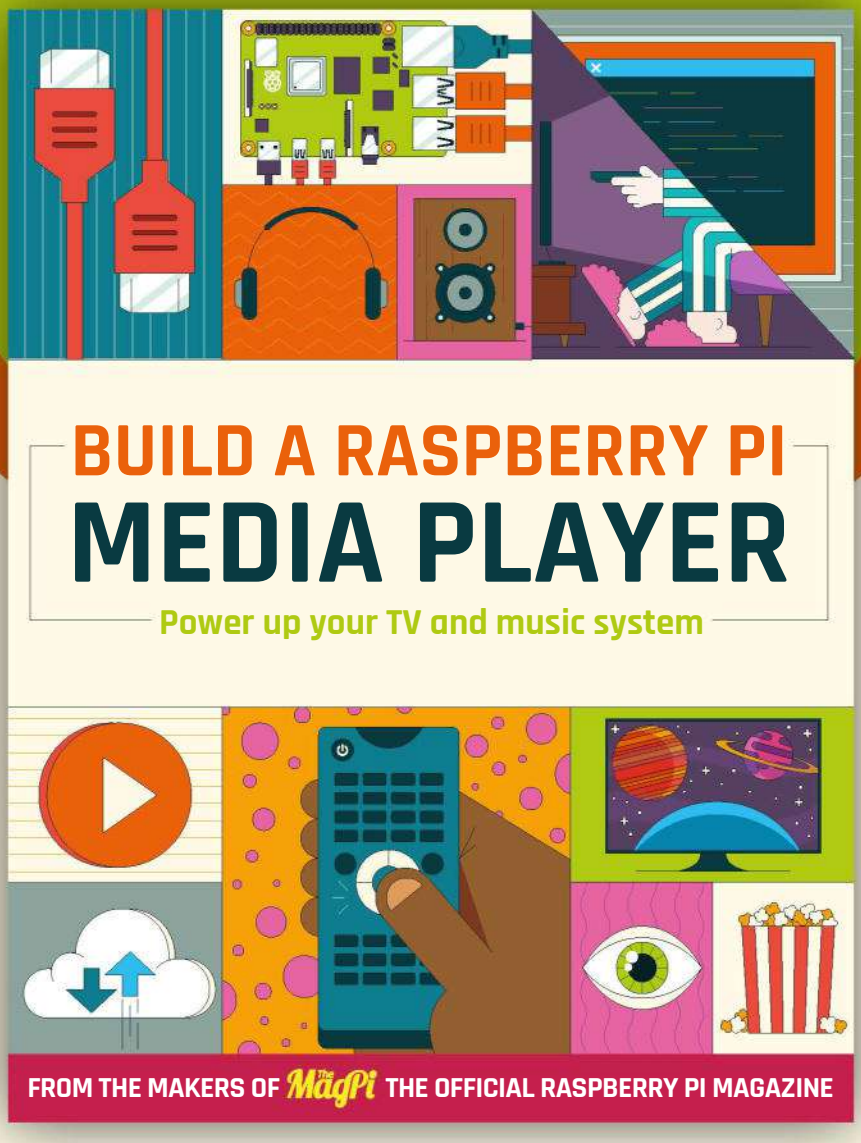
Where can you find Raspberry Pi next?

- Next location Maker Faire Hannover
- Where Hannover Congress Centrum, Hannover, Germany
- When Friday 19 August and Saturday 20 August

Raspberry Pi is proud to partner with Approved Reseller BerryBase to be at Maker Faire Hannover for the first time ever. Come and meet members of the Raspberry Pi team, learn about their latest products, and share what you've made with Raspberry Pi technology.

magpi.cc/mfhannover23

Your FREE guide to making a smart TV


BUILD A RASPBERRY PI
MEDIA PLAYER
Power up your TV and music system
FROM THE MAKERS OF The MagPi THE OFFICIAL RASPBERRY PI MAGAZINE

magpi.cc/mediaplayer

WIN ONE OF FIVE DESKPI PRO V2

Fancy making a media player after reading this month's big feature? Then you could do with a new and fancy case, like the DeskPi Pro V2. It slots in nicely into any media centre and keeps all the ports open for easy connection.

In association with The PiHut

Head here to enter: magpi.cc/win

Learn more: magpi.cc/deskpiprov2

Terms & Conditions

Competition opens on **27 July 2023** and closes on **31 August 2023**. Prize is offered to participants worldwide aged 13 or over, except employees of Raspberry Pi Ltd, the prize supplier, their families, or friends. Winners will be notified by email no more than 30 days after the competition closes. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. Participants agree to receive occasional newsletters from The MagPi magazine. We don't like spam: participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered. Winners will be contacted by email to arrange delivery. Any winners who have not responded 60 days after the initial email is sent will have their prize revoked. This promotion is in no way sponsored, endorsed or administered by, or associated with, Instagram, Facebook, Twitter or any other companies used to promote the service.

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Novelty

Using Raspberry Pi outside of the day job hits different, according to **Rob Zwetsloot**

Raspberry Pi has always been part of my job. When it was first released, I was writing for a (now defunct) Linux magazine and we were very keen to use it to write tutorials and make fun things with. It beat talking about how much people disliked GNOME 3 any day, and I did end up with a small army of robots in the process.

While I've made many, many (many!) Raspberry Pi projects over the last decade or so for tutorials and such, I still get a little extra spark of joy when I'm making something outside of a work setting. Last month I wrote a guide on how to create some interactive streaming lights with a Raspberry Pi Pico and some NeoPixel LEDs, and that had started off life as a personal project. Using it in a context outside of the magazine in my day-to-day (sorta) life has a different level of novelty to me.

In plain sight

That's not to say I never use Raspberry Pi around the house. At the very least, I always have a Raspberry Pi NAS running in the background, and I've had a Raspberry Pi media PC for about as long as media centre software has been available for Raspberry Pi. These utilitarian builds live in the background though and are a bit less creative or unique.

> I still get a little extra spark of joy when I'm making something outside of a work setting

I think that's one of the reasons Raspberry Pi has taken off so well. You can have a functional project, a seasonal project, or a more ostentatious one and Raspberry Pi or Pico is usually the best (and cheapest) thing to use for the job. It's also how we can have many fantastic projects each month in the showcase section at the beginning of the magazine.

One more thing

There's always another Raspberry Pi build I want to do. Right now, I'm thinking about interesting LED customisation of a LEGO castle or a Gunpla model, and maybe upgrading the decorations on my Christmas tree. Not sure why it's mostly light stuff right now, but I'm sure something else will pique my interest – and when it does I'll probably get to write about it for the magazine.

Whether you have an outlet like me for your project (and I understand my situation is fairly unique) shouldn't really matter – what matters is whether or not you turn on your project and think "oh cool, I made that." It's certainly helped me through other parts of my life.

AUTHOR

Rob Zwetsloot

Rob would ideally like to make a Wallace and Gromit-style contraption that gets him out of bed in the morning with some toast... all powered by Raspberry Pi.

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